Systems analysis of Emerging IPTV entertainment platform: Stakeholders, Threats and Opportunities.

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ABSTRACT

Why do certain types of companies, goods, services survive and others do not. Why does one set continuously reinvent themselves and others wither away and die? Why does Cisco continue to provide exciting and innovative networking products, while companies like Cabletron die?

Several academics believe that a dominant factor is that winners are able to create robust and effective product platforms. These platforms are able to cater to changing customer needs. On the winning side, the platform leader is effectively able to manage the various conflicts that are present in the platform ecosystem. On the loosing team, often there is no platform leader!

I believe that effective platform leadership, platform architecture play a key role in product success.

In this thesis, I plan to compare two large platforms. These are the IPTV platform and the conventional cable based TV platform. Both are competing with each other to provide similar services to the same customer set. I have coined the term 'Mega Platform" to

describe such large platforms. . As part of this comparison I will develop a set of metrics or comparison points which will help compare the two competing platforms.

Please note that the purpose of this thesis is not to prove that there is a strong correlation between platform success and market success.

Thesis Supervisor: Professor Michael Cusumano
Title: Professor of Management, Sloan School of Management

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I also would like to acknowledge the great sacrifices my wonderful wife Vineeta made to put me though the program at MIT. Without her efforts, I would not have completed my studies. My precious son, Aniketh is too young to understand all this. However, his enthusiasm for all things connected to "MIT" helped me with my studies and thesis writing. I hope he gets a degree from MIT. Finally I would like to thank my parents who encourage and supported me in this pursuit.

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This thesis is dedicated to my grandparents.

Chapter 1 Introduction

A most logical question to ask at this stage is, "What is IPTV?" In this chapter I will define the meaning of IPTV for the purpose of this research effort. However, before I do so, we will need to understand some related concepts. At this point, my initial working definition is:

"IPTV is a new way of delivering video entertainment and more."

This society has been a witness to several sweeping and high impact technological changes in the past five to seven decades. In particular, the evolution of television technologies and the emergence of internet technologies have laid the ground work for IPTV. We shall first understand the evolution of television and entertainment technologies and their present day confluence. Section 1.1 provides an overview of the technological forces at play. Section 1.2 does the same with business trends and customer behaviors.

Once we understand all the relevant business and technology trend and factors, I shall endeavor to redefine the term IPTV.

1.1 Technology Trends

In this section I shall examine the evolution of television and internet technologies. I shall then point out the convergence of these two technologies and how that affects IPTV.

1.1.1 Evolution of Television

Electronic Televisions in the earliest days were based on vacuum tubes, were bulky and were black and white. Programming was broadcasted over the air and was received by an individual consumer directly via television receivers with antennas for signal amplification. This implied that the programming was sent out to "everyone" who cared to tune in. The communication was analog. Technical details of analog communication are captured in one of the appendices.

In the 1950s, the RCA Corporation invented the color television. This was a significant event in the evolution of this technology. Transmission was still done using terrestrial broadcast.

In areas where terrestrial reception was poor, cable industry started laying coaxial cable to deliver television. However they expanded into other areas where reception was acceptable.

Cable providers sent television signals over a dedicated, controlled and managed channel to the customer. The consumer would pay for the service. Cable providers claimed that the consumer received better quality video and had more choices. I agree with the latter, though the former is debatable. The major innovation here was that the entertainment provider was controlling the path TV signal would take from the sender to the receiver.

The next two major technical breakthroughs are perhaps the moist significant. These are *digital television* and *switched digital video*. Both represent quantum leaps in the delivery of video and more. They also act as strong enablers of IPTV.

Digital Television

A big technological innovation was the advent of *digital television (DTV)*. DTV is a technology that enables the transmission and reception of video signal using digital technology. This is in contrast to traditional television which accomplishes the same using analog signals. The information broadcasted in the video is actually captured in the

stream of bits and bytes using digital modulation techniques. It can also be compressed and encoded. Special equipment is needed to receive and decode the signal. This equipment is in-built in the television sets or can be purchased stand alone [9].

DTV has the following advantages that are directly relevant to this subject:

- Superior Picture quality
    - Television viewers have often been subjected to ghost images and snow on the TV set. Digital technology eliminates such problems. Ghost images are essentially two copies of the same image superimposed on each other which makes the picture blurred.
- Lends itself to new consumer entertainment options like TV on demand, personalized TV.
    - In a digital IP TV network, only the information requested is available on the network. I shall later in this chapter discuss the advent of multicast and unicast techniques. The result is the emergence of new consumer patterns. Customers can choose what they want to watch and when they want to watch it!
- Ability to share communication pipes and communication hardware for different services.
    - When a service is offered on a digital platform the information is ultimately stored and processed in the form of 1s and 0s. Whether the service is internet access or it is telephony, the communication pipes see them as a string of 1s and 0s. Such commonality is key in sharing of these pipes for various services. It would be fair to point out, that in reality the communication equipment still needs to have in build intelligence to deal with these different yet similar services.
- More effective content storage
    - Digital content is stored in binary 1s and 0s and can be stored on random access hard drives and other new media which is originating from the computer industry. This medium is easier to store, easier to manage and

even cheaper than the traditional linear media used by the entertainment industry.

- Digital content can be compressed furthering the effective density of the storage platform.
- Digital storage can be encrypted.
- Digital content has more effective intellectual property protection than linear tapes.
- Digital content can easily be replicated.
- Digital storage has superior access time and can easily be transformed from one format to another.

- More efficient use of communication infrastructure.
  - Advances in digital compression techniques can pack more information into communication pipes. Error correction is simpler for digital channels, and it can be automated. In fact, one analog channel can be replaced by several digital channels!

More information about Digital television is provided in one of the appendices.

Switched Digital Video

In the world of television and video content delivery, there exist three broad technologies:

- Broadcast content delivery.
- Multicast content delivery.
- Unicast content delivery.

The industry is moving away from Broadcast and towards Multicast and unicast content delivery.

As mentioned earlier, broadcast video is sent to everyone who has a powered-on receiver. Multicast video is only sent to those who choose to join the group. Unicast is sent to one person only.

In the multicast/unicast world, video content is placed on the network only when a consumer chooses to watch it. This is also known as *Switched Digital Video (SDV)* [11].

In the next section I shall provide an overview of the evolution of internet connection related technologies.

1.1.2 Evolution of Internet connectivity

In this section I will primarily focus on the jump from dial up connection over the telephone line to broadband internet.

Dial up connections.

Internet access became a household phenomenon with dialup. When households first started getting internet access, it was over the telephone line. The user employed a dial up modem to establish a data connection. This process was cumbersome and the speed was low. As dial up technology evolved, line speed increased but never went beyond 56k.

Additionally, when a telephone line was used by a modem, it could not carry voice communication. Incoming voice calls would either not be connected, or would break the data session.

Please note that setting up the data session involved, "dialing a number". Consumer would be billed for making a call to that number. This charge was in addition to the monthly charge from the service provider. In the US, the service providers provided local phone numbers for customers, thus minimizing the impact of telephone charges.

Broadband connections.

The next step in the evolution of internet technology was the arrival of DSL technologies. The speed was 10 times faster than dial up. The user could leave a computer connected to the net and did not need to establish connection every time. DSL allowed simultaneous voice and data sessions.

DSL had one major issue. Downstream and upstream speeds were unpredictable. A user's distance from the central office was a factor. In several areas, DSL was not available.
The cable companies were developing cable modem based broadband connection. These were faster than DSL and the speed was more predictable. Today cable modems have become the dominant broadband access vehicle in the US.

Other technologies

Several new technologies are now emerging, some driven by the wireless industry. Some of them like Wifi are used in conjunction with existing broadband techniques. Others like EVDO represent a totally new and standalone way of internet access. It would be very interesting to talk about those, but they are not relevant to this research.

1.1.3 Implications for IPTV

The next question is why are these historical lesson important?

If you examine the three internet access methods described in the previous section, they all have the following in common:
Service providers' piggy backed data services on another existing service.

Data Service	**Existing technology leveraged?**	**New wiring to customer home needed?**	**Did data service provider need to own the pipe?**
Dial up.	Telephone Line	No	Yes

Data Service	Existing technology leveraged?	New wiring to customer home needed?	Did data service provider need to own the pipe?
DSL technologies	Telephone Line	No	Yes
Cable modem broadband	Cable television	No	yes

Table 1 Internet access methods

In the mid 90s, the telcos did not have a dedicated television network to the end customer. Some of them had a dedicated phone network to the home. The cable companies did not have dedicated phone network to the end customer, but they had the cable/TV network.

As the concept of "triple play" and "quadruple play" came into focus, telcos and cable providers started to offer more and more services. In fact they both began to offer, voice, video and internet access. However there was a problem, their networks were designed to provide a certain service and it was not easy to retrofit a new service on it.

Verizon started providing internet access by DSL over existing telephone lines but ran into technical issues. It chose to develop a brand new network and started running fiber to the customer's home, spending billions of dollars in the process. The cable companies have enhanced their networks and developed technologies to be able to provide voice, video and data on their networks.

IPTV is benefiting from this evolution. Consider the following aspects:

- IPTV service can be provided over the existing broadband or video connection to the home. In some cases the providers are choosing to upgrade the pipe as part of a longer term plan or the pipe needs to be upgraded for technology reasons.
- In its broadest sense (including internet TV), the service provider does not need to own the connection to the customer home. This is very similar to the dial up case.
- The above two bullet points are enabled by the use of the IP Protocol as defined in rfc791 and derived work [13].

The confluence of IPTV and broadband access represents a significant milestone in the evolution of the technology. Cable and Telcos have existing relationships with customers and they have network connectivity to the homes. IPTV becomes easier to introduce because of that. Other IPTV providers will leverage the broadband connectivity that the customer has to create new and innovative service. This is evidenced by the success of 'youtube'.

1.1.4 Summary of trends

I will now wrap up this session and list the various technological trends at play. In summary the following key technical factors that are influencing IPTV:

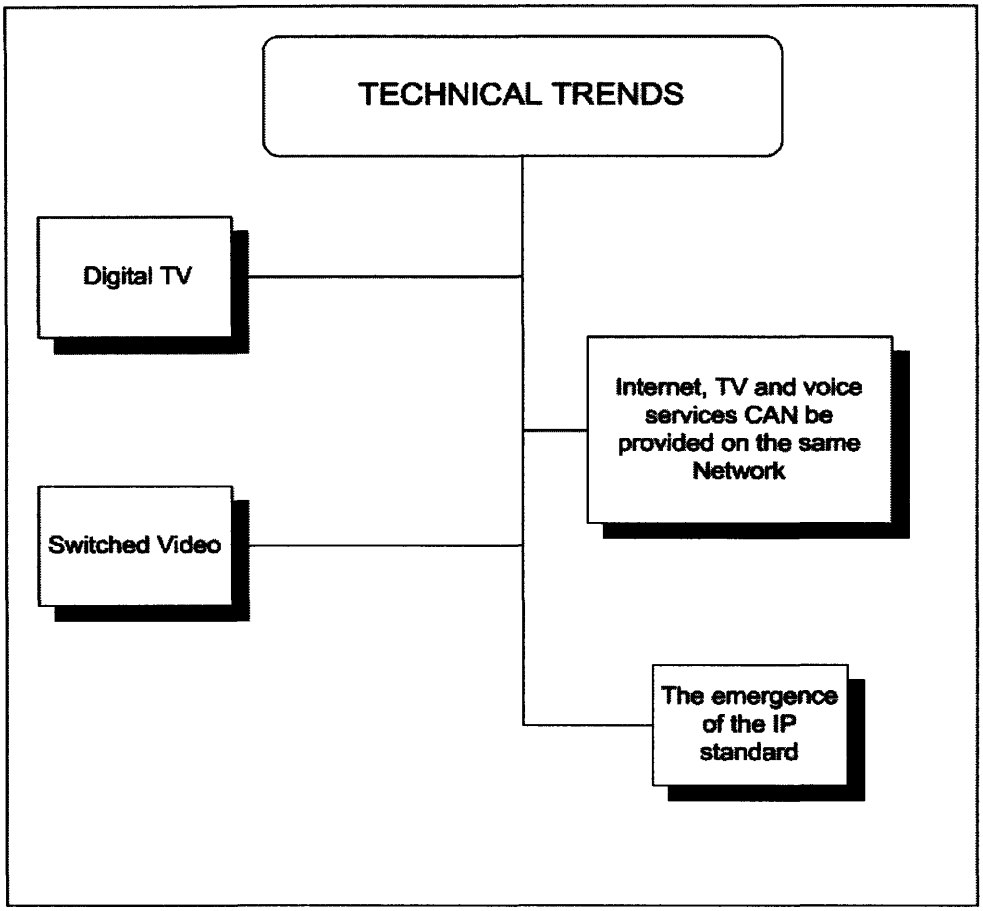

Figure 1 Technical trends that enable IPTV

1.2 Evolution of consumer choices and behavior.

Changes in technology, business practices and consumer behavior often go hand in hand. In this section, I focus on trends in consumer choice and business practice that have implications for IPTV.

In a recent book titled, Invisible Engines [5] the authors introduced the concept of an "N" sided platform. The world of television is actually a three sided platform:

- Content providers need to have a consumer base to develop content.
- Consumers are interested if content is relevant and suits their entertainment needs.

- Advertisers engage in business based on the strength of the consumer–content link.

In section1.2.1 , I compare the traditional business model of video delivery with the new, emerging IPTV based business model. Finally, in section 1.2.2 I will summarize the business trends relevant to IPTV.

1.2.1 Business Models

The traditional model of this relationship is summarized in the figure below:

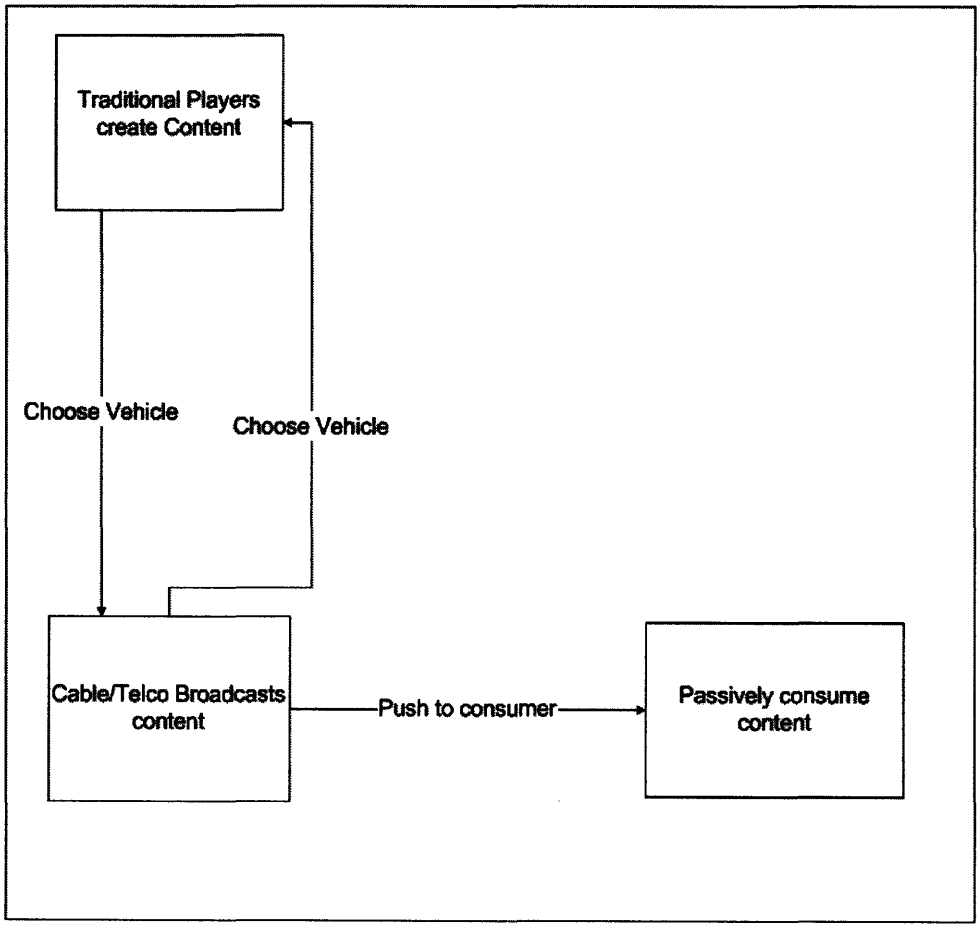

Figure 2 Traditional Business environment

In the traditional model, content creators create video entertainment and deliver it to television providers. These providers in turn would be getting the entertainment to the end customer.

It should be noted that several content creators were also content distributors and vice versa. For example, Time Warner both has a movie business as well as a cable business. The customer did not interact with the content creator directly.

The above mentioned traditional model has evolved and several major changes have taken place. With the emergence of new types of content providers, the users and the content providers have linked. A stellar example is www.youtube.com where all content is generated and viewed by users. Please note that the service provider is not providing value add in this relationship. The service provider simply provides the infrastructure. The traditional service providers see this trend and are responding with interactive TV, video on demand etc. This further re-enforces the business push for IPTV.
The new model for this relationship is as follows

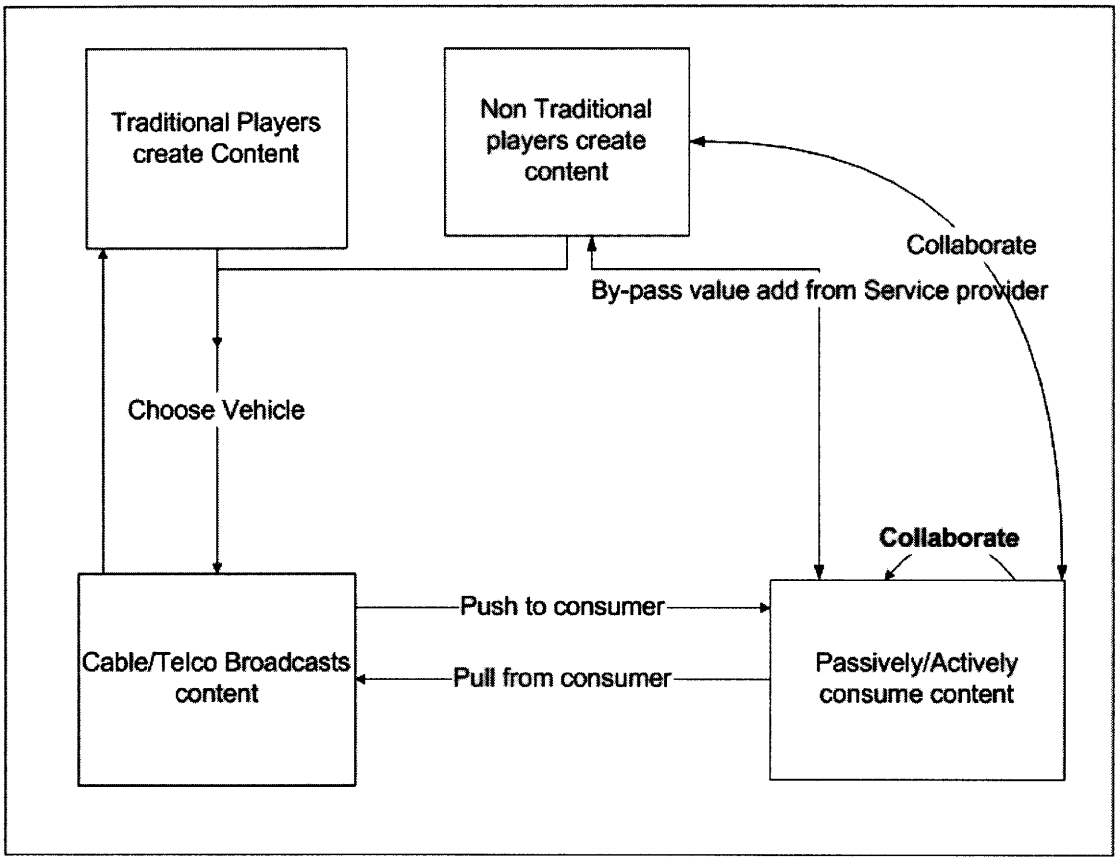

Figure 3 Emerging business model

1.2.2 Business Trends

Finally, I would also like to capture the key business trends that correspond to the technical trends discussed in section 1.1.4

The following figure summarizes the key trends:

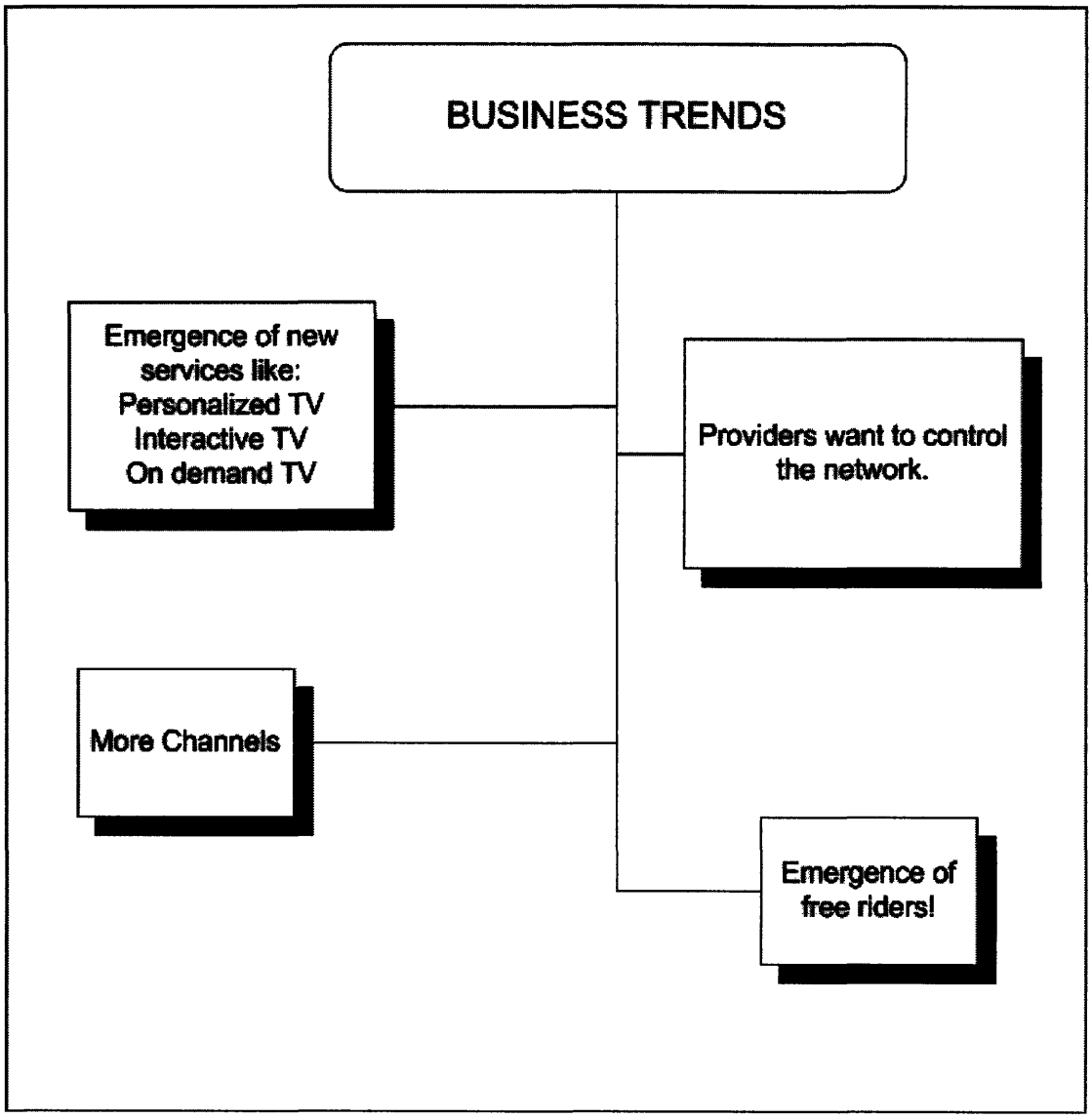

Figure 4 Business Trends

Traditional television was represented by a fixed number of channels and entertainment was primarily a passive viewing exercise.

In the new world of IPTV, consumer behavior is different. Digital TV allows packing more channels into existing infrastructure. Customer now has access to a much larger number and types of channels. They can choose the package of content they are interested in.

Consumers are no longer tied to schedule set up the service provider, they can view programming at their own convenience.

New kinds of programming are emerging where the consumer is part of the entertainment and may even help with story line etc. This particular line of entertainment is in its infancy, but it can use the video game industry as an example.

Cable companies like Comcast and telecommunication firms like Verizon are in the process of upgrading the infrastructure to the customers' home. This will let them deliver high impact services. They then offer a complete gamut of solution with the billing package designed to lock in all revenue potential from the consumer. The free riders want to use this infrastructure as simple pipes to deliver their own content. This is an ongoing business tussle, unlikely to be resolved in the near future.

1.3 What is IPTV?

Let us now get back to the original question. What is IPTV?

If you search through technical and business literature on this subject, you shall find several definitions. For the purpose of my research, I am using the following definition: IPTV is a system of delivering video entertainment that has the following characteristics:

- Significant part of system can be used for delivering voice and data as well.
- The technology allows the video content to be time shifted at the consumers' discretion.
- The technology allows the consumer to choose a now traditional media vehicle to view content. This is of course in addition to the television.
- Uses digital technology for coding, transmission of information.
- Supports push as well as pull modes of content delivery.
- Supports broadcast as well as switched broadcast (multicast or unicast).

- The service provider owns or controls the network from its facilities to the consumers' home. This network is separate from (and connected to) the public internet.
- The technology is based on or is being migrated towards IP protocol.

For the purpose of this thesis we shall consider the following two IPTV platforms only:

- Telco based IPTV, example Verizon and PCCW.
- Cable based IPTV, example Comcast.

In the rest of the thesis I will attempt to study these two platforms in detail and then compare them.

This study shall not dwell on non traditional video providers. These include:

- User generated content that is disseminated over the internet. Example, www.youtube.com (You Tube)
- Internet only content generated by cable/telco players. Example, http://www.comcast.net/home.html (The Fan)

Several academics refer to the above two examples as internet TV. It is a special kind of IPTV. I shall not be covering these topics in this study.

1.4 Structure

This thesis is structured in to the following chapters:

Chapter-1:

Introduces the subject of IPTV and discusses the underlying business and technology trends.

Chapter-2:

Introduces the concept of a platform and how it is relevant to IPTV.

Chapter-3:

Discusses the technology behind telco based IPTV.

Chapter-4:

Explains the technology of Cable based IPTV.

Chapter 5:

Describes a model which is then used to compare cable and telco offerings.

Chapter 6:

Thesis concludes and key findings are summarized. This chapter also describes some directions for future work and research.

Research and background material for this thesis is sourced from journals, trade publications, company white papers etc. I also have a questionnaire which is sent to a few key industry players for feedback and comment. Please refer to the appendix for the document.

Chapter 2
Whole product solutions, Platforms and Mega Platforms

In this chapter I introduce the concept of *Mega Platforms*. IPTV and related services are built upon a large platform. Such platforms go beyond the accepted definitions of platforms and whole product solutions.

I shall first define the concept of whole product solution and concept and then introduce a new construct dubbed "Mega Platform".

2.1 The whole product concept

Geoffrey Moore makes extensive references to the concept of "Whole product solution". This is a concept relevant to both product managers and marketers [6]. A product needs to solve a substantial portion of a customers' problem and has to provide substantial value for the customer to purchase it. Often the actual product has marginal utility, but the product in conjunction with complements can provide substantial value.

In the attached figure I provide some possibilities of add-ons that will create a whole product solution.

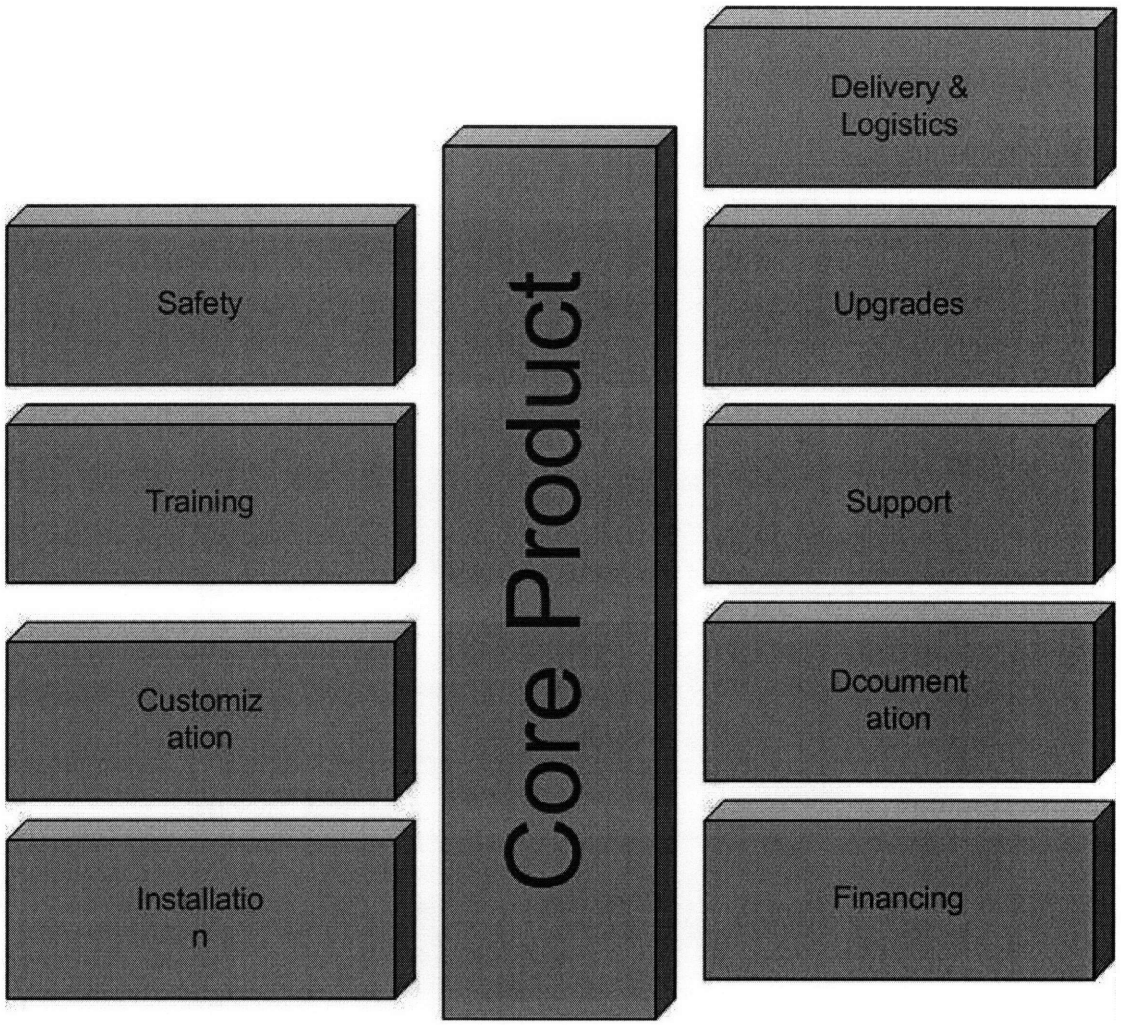

Figure 5: Whole Product Solution

The producer of the core product needs to assemble the rest of the pieces to complete the whole product solution.

2.2 Is whole product enough?

If an enterprise develops a whole product solution, is that enough? In my opinion, in the world of technology, it is often not enough

Technology solutions and products are often extremely complicated and they have the following characteristics:

- The parts that make up the solution or product may be as complex as the total solution.
- Interfaces between the parts need to be well defined.
- Various parts are interlocked and interdependent.
- Various suppliers are interlocked and interdependent.
- Leadership and balance of power between players often evolves and changes.

In the fast paced world of technology development, whole product solution needs to be redefined. Whole product solution is actually delivered by several companies in the industrial ecosystem. Further, the leader may not be able to exercise significant direct control over partners delivering the whole product solution. Please note that this represents a new extension to the concept of whole product solution defined by Moore.

2.3 Enter Platforms.

In the fast pace world of technology development, whole product solutions are often delivered by several companies working together. This leads to the concept of a platform. My advisor, Dr. Michael Cusumano has done seminal research in this subject. Gawer and Cusumano are the creators of the concept of industry platforms [1].

The concept of product platform is defined in several ways. For the purpose of this thesis *I am defining a product platform as a set of systems, interfaces that result in an architecture which is a building block for goods and services for one or more market segments. Perhaps, a platform often is a combination of whole product solutions.* Interestingly a robust platform will result in several viable whole product solutions too. I recognize the circular nature of this dependency is challenging to grasp. The definition discussed in this section is captured in the figure below.

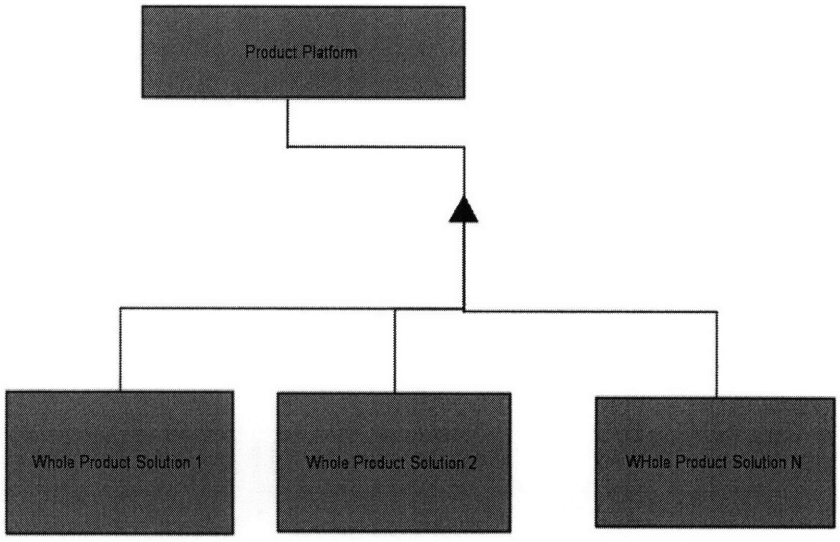

Figure 6: Platforms

In this thesis, I shall compare two platforms, telco IPTV and cable based IPTV. It is important to note that when platforms like these are vying for dominance the competition is more than just between platforms. There are at-least two levels of competition in this space. Platforms are competing to get the customers dollars. An example of such would be Windows and Linux. Another level of competition occurs at the level of the platform components. For example, companies writing drivers are competing with each other while they may be part of both platforms.

Since competition is on two orthogonal planes, innovation and development at the component level may not reinforce that happening at the platform level. Nor would it necessarily contribute to the evolution of the platform. For example, a networking driver company may producer a faster wifi driver for a Solaris machine. The need of the product

platform may however be intelligent power management of the wifi card to make the platform a compelling customer sell.

In Platform leadership [1], Gawer and Cusumano comment that companies in the platform ecosystem need to contend with the following three issues:

- The ecosystem or a part of the ecosystem needs to maintain the integrity of the platform. Platform evolution needs to be managed.
- Market leadership for the platform environment has to be established and will then evolve.
- An organization that is able to manage the evolution and growth of the interdependency and innovation in the various components emerges as the platform leader. The platform leadership is then framed in four levers, which are described below.

Any discussion on platform leadership is incomplete without an overview of the four levers that were defined by Gawer and Cusumano[1].

- *Scope*: Innovation leading to the development of a superior platform can either be done inside the company or outside. The platform leader needs to decide how to distribute that load. Internal innovation calls for significant in-house investment in research and development. The leader in most cases gets to cement its leadership position by doing so. Alternatively the leader can rely on external innovation. This is cheaper and faster and creates an ecosystem of complimentary products. The danger here is that the leader may loose control over the platform to a "wannabe". In most cases the leader finds a middle ground. They cannot create all the complements themselves, at the same time they cannot rely on external entities to create all the complements either.
- *Product technology*: The platform leader and other key players in the ecosystem need to figure out how much of the platform architecture they would like to open up. The opening of architectures does not need to be a binary activity. Companies

can be very creative in defining how much openness makes sense for their business needs. Several other questions also have to be answered. How much modularity will the architecture have? Will the interfaces be defined by standards or will they be close?

- *Relationship with external complementors*: Platform leader needs to have a strategy on how they will deal with the collaborators. Should the relationship be collaborative or competitive? How will conflicts of interest be handled?
- *Internal organization*: Internal organization structure should be such that there is no internal conflict of interest with the platform direction.

Later in this document, I will analyze the four levers from the perspective of the two IPTV platforms I am considering.

2.4 Mega Platforms.

As I think about applying the concept of platforms to IPTV and cable based TV, the sheer magnitude of the product makes me extrapolate the concept platform concept to that of a "*Mega Platform*".

A mega platform is defined as a robust collection of tightly coupled product platforms, connected by standards based interfaces and targeting a related set of market opportunities and customer problems.

In the following figure I have captured the relationship between, whole product solutions, product platforms and mega platforms.

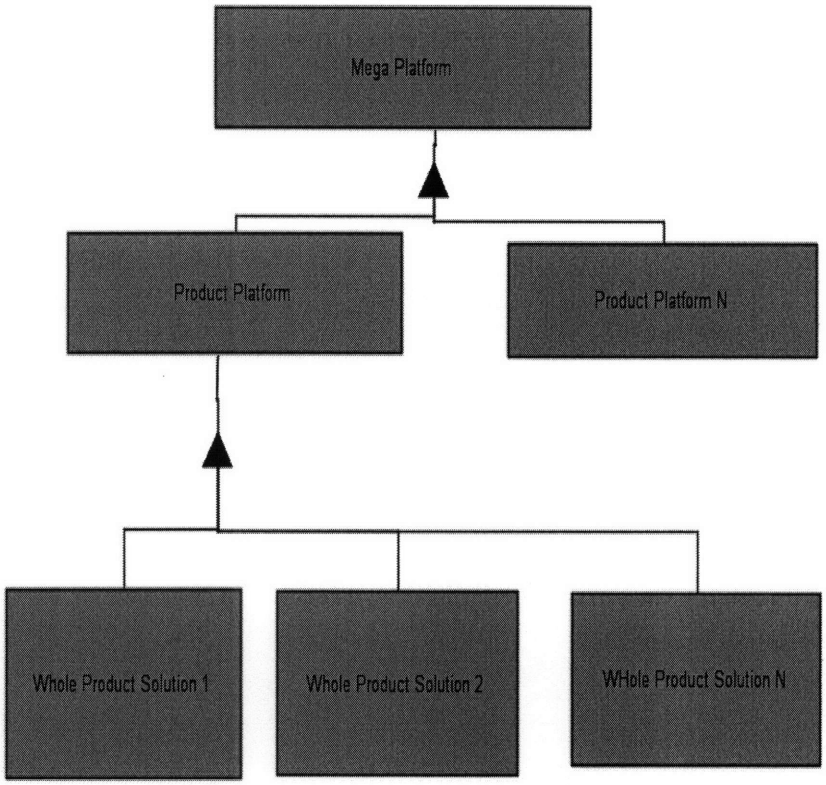

Figure 7: Mega Platform

Chapter 3 Telco IPTV Architecture and Deployments

In this chapter I explore the architecture of telco IPTV. This chapter also provides an overview of important IPTV installations.

3.1 Concepts in System Architecture

In their seminal work on architecture, Maier and Rechtin, have introduced the concept of "view". This is a representation of system from a certain perspective. Hence system architecture can be represented by various non overlapping views.

The following six views are considered critical for any system architecture analysis [22][23]

View	Description	Implication for IPTV
Objective	What client wants	This view would provide a perspective on the features provided by IPTV from the consumers' perspective. This material was covered in chapter 1 so I shall not revisit it in this chapter.
Form	What the system is	For the purpose of this research the network design would be a good proxy for *Form*.

Functional	What the System does	IPTV platform can be broken into various functional pieces. In real deployments any given functionality can be spread across several components.
Performance	How effective is the system in performing its tasks	This view is relevant from the perspective of comparing the Telco and Cable offerings
Data	Information retained in the system and its interrelationships	A pure engineering thesis would find this view very relevant. Since my work is at the intersection of business and technology I will not dwell upon this.
Managerial	Process by which the system is managed and constructed.	The managerial view represents the *control plane* and the *management plane* of the relevant IPTV platform. Please note that control plane refers to the technology that manages the operational aspect of a network. Management plane refers to the configuration and monitoring aspect of running a network. This view is marginally relevant, unless one of the IPTV platforms has unique control/management plane capabilities.

Table 2: Six views on IPTV platform architecture [22][23]

A network level form view is covered in section 3.2 . Section 3.3 provides a functional look at the architecture. After that, the write up focuses on a few selected deployments.

3.2 Form/Network view

3.2.1 Overview

Telco IPTV network has three major parts. The *headend* or *super-headend (SHO)* which receives programming from external sources, the *access network* which provides programming to the customer and the *core network* that sits in the middle and enables the transfer of content.

Figure 8: Telco IPTV Network

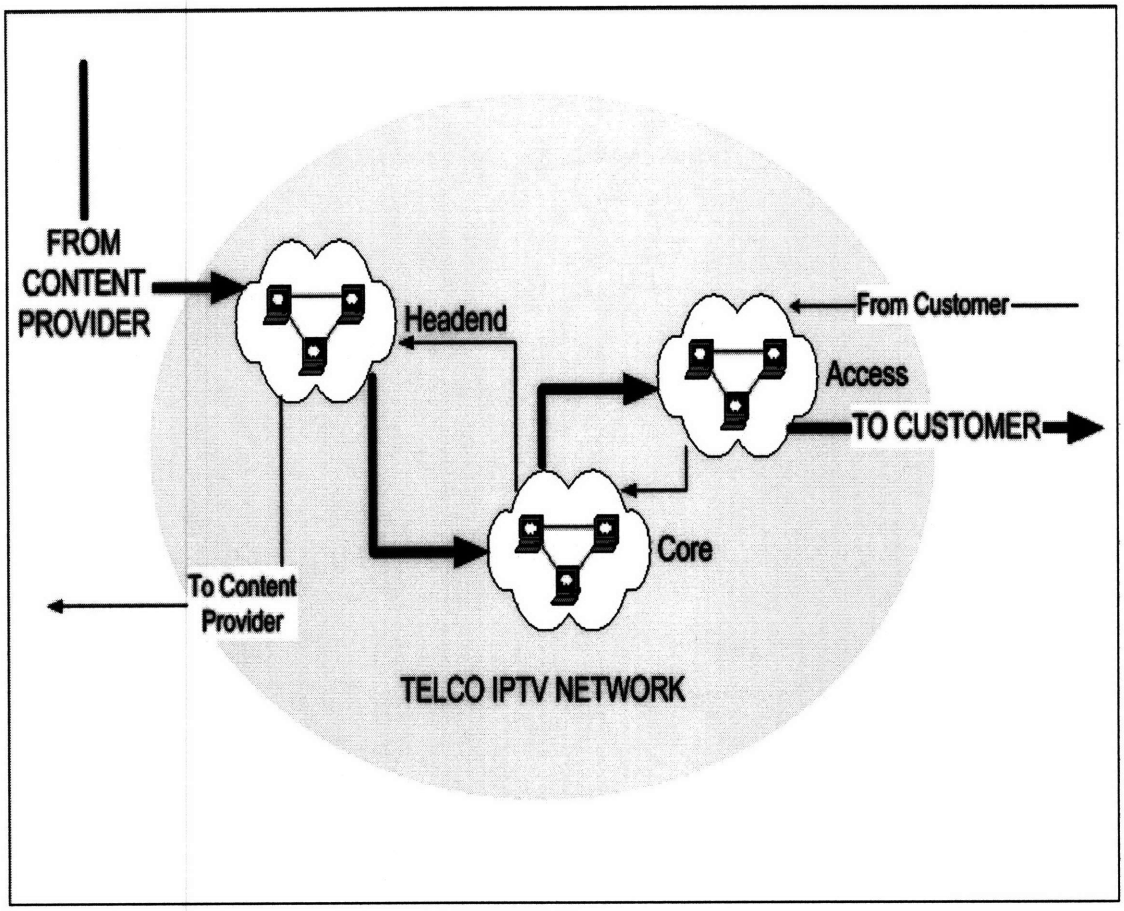

Figure 9: Telco Network

The figure above shows a very high level breakdown of network structure and the flow of information. The astute reader will notice that the arrows are in both directions. The arrows going from content provider to customer are thicker than the arrows in the other direction. This is to account for the interactive nature of IPTV with the caveat that data flow is heavier from content provider to customer.

Please note that the original ITU architecture defined in [21] fails to represent the interactive nature of the service.

In the next three subsections, I will provide more detailed information about each part of the network.

3.2.2 Telco Headend

The headend is the starting point of the telco network. It interfaces with the content providers on one end and with the telco core network on the other. In this section I will first describe the functionality provided by the headend and then describe the network view.

Functionality provided by headend.

The headend has the following roles to play [19][21]:

Role	Role Description
Ingestion	The headed is the entry point for video content into the Telco network. In industry parlance the process by which video content enters into and is processed by the headend is termed as *ingestion* [15]
Signal Conditioning	Headend is responsible for converting analog signal to digital signal. In the case of digital signals, headend is responsible for ensuring that the signal has the correct encoding and bit

	rates. This aspect is discussed later in this section.
Signal Preparation	Headend is responsible foe preparing the incoming signal for distribution to the customer. This involves changing the signal to IP packets,
Content and Asset management, modification and storage.	Headend is responsible for storing content, modifying content and inserting/deleting content as dictated by business needs.
Billing	Headend reconciles usage and billing.
Digital Rights Management	Headend is responsible for adding a DRM jacket to content wherever applicable. This prevents unauthorized use of content
Interfacing	Headend provides an interface to the content provider.

	Headend also provides an interface to the core network. These interfaces are defined by technical standards.

Table 3 : Headend Functions [19] [21]

Let us start with video content. The content can either be *external* or *internal*. For example, if the telco offers video on demand service, a popular movie may be stored on a video on demand server inside the headend. On the other hand, a television channel originating from ABC networks is external content.

Internal content is stored in a format compatible with the network. However internal content may or may not be in the correct format. Lets us now focus on the processing of external content.

External Content Ingestion process and sequence of events.

External video content can be one of two types, Analogue or Digital. Fro example, ABC networks broadcasts its content in analogue signal though it is going to be switching to digital only in the future. External content can be delivered via terrestrial broadcast, fiber link or satellite. Content can come from either a content provider or a content aggregator.

Content ingestion is a multi step exercise. The process is captured here[17, 18]:

Step number	Step title	Description
One	Encoding	This is the process by which analog content

Step number	Step title	Description
		is converted to digital content. Digital video can be in one of several formats. The popular ones are MPEG 2 and MPWG4 AVC
Two	De-multiplexing and rate shaping	Digital feeds coming from one source are typically lumped together. This is the process by which the individual streams are separated. The bit rate is also manipulated to confirm to the standard in the network.
Three	Transcoding	This step changes the digital coding of the stream from one format to another. For example consider a new telco headend uses MPEG 4, while a legacy digital provider encodes the feed in MPEG2. This step will convert incoming MPEG2 to

Step number	Step title	Description
		MPEG4.
Four	Content and Asset management	This step refers to the addition, removal or modification of incoming content. For example, the headend may choose to insert advertisement in the feed.
Five	Rights and access management	Digital Rights management systems in the telco headend ensure that content is available only to those who are entitled to receive it and for the time period for which they have the entitlement.
Six	Encapsulation	The digital stream needs to be converted to a format that can be sent across communication pipes. A popular choice is

Step number	Step title	Description
		to encapsulate the stream into IP packets
Seven	Transmission	The content is then sent out to the core network for further processing

Table 4 : Ingestion Steps

It is important to note that these steps may not necessarily be followed in this order and the actual sequence is specific to the deployment [17, 18]

Finally to wrap up the headend section I have captured a network view of a generic telco headend below:

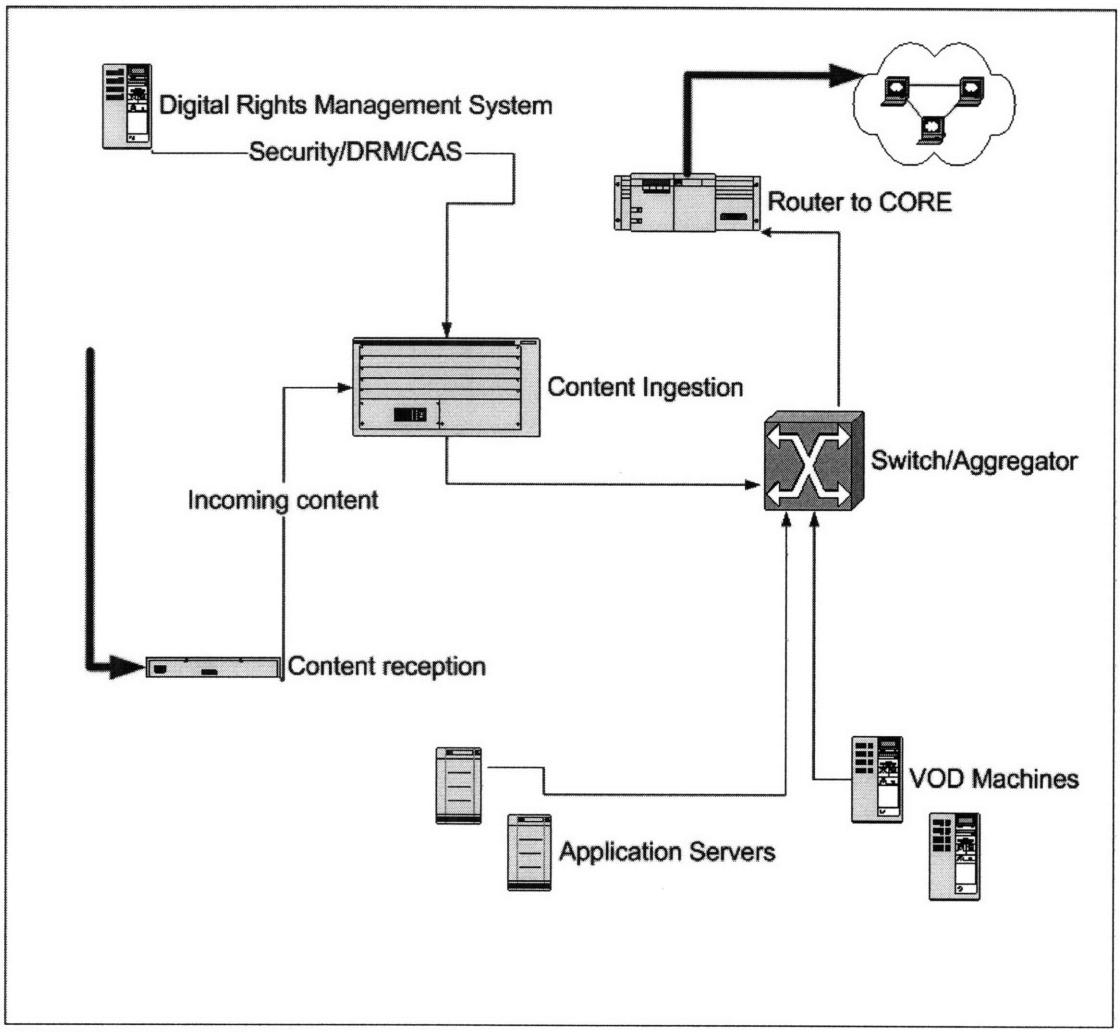

Figure 10 Generic Telco Headend

3.2.3 Core Network

The core network is the backbone of the telco network within a service region and is a collection of transport pipes and nodes called *Video Hub Office* or VHO. It interfaces with the headend on one end and with the telco access network on the other. In this section I will first describe the functionality provided by the Core and then provide a network view of the core.

Functionality provided by Core

The core has the following roles to play [21]:

Role	Role Description
Transport Provider	The core provides bandwidth and transport between the Headend and the various service area
Local Content	The VHO in the core essentially acts as a little headend. It sources part of its content from the headend and part from other sources. For example, if there is a local new channel, it will provide local news to the relevant VHO. The VHO will insert the local news segment in the main news program delivered from the headend
Emergency Broadcast Services	The role is self explanatory.
Acts a mini headend	Core inserts local content, and portions of the DRB, VOD, billing and application capabilities can be houses here too.

Role	Role Description
	For example, if a given area heavily uses video on demand, than it makes sense to move the VOD server from the headed to the VHO or perhaps even closer to the customer!

Table 5 : Core Functions [21]

A network view of the system core has been described in a case study focused on designing an efficient IPTV backbone and is reproduced in verbatim [25]:

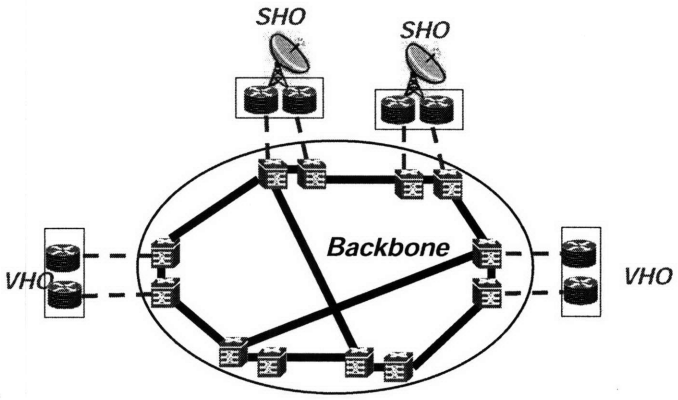

Figure 11 : Network View of Core [25]

3.2.4 Access Network

This part of the network is also referred to as the *last mile*. Its main function is to interface with the customer home and it is responsible for providing service to customer premises. The VHOs serve a series of *Video Serving Offices (VSOs).* Each VSO then

connects to several customers. The VSO collective along with the access line comprises the Access network.

In this section I will first describe the functionality provided by the access network. After that I shall provide a network view of the access network.

Functionality provided by Access Network

The access network fulfills the following roles [21]:

Role	Role Description
Network translation	Translates content from backbone technology to access technology. As will be described later, access technologies vary across deployments and providers. Major US telcos use similar, yet different access technologies.
Service customer home	Responsible for providing adequate bandwidth, uninterrupted service and appropriate quality of service.

Table 6: Access functions [21]

Overview of Telco Access technologies.

There are two major types of access technologies employed by telcos, DSL variants and FTTX variants.

The older technology is *DSL* or Digital Subscriber Line. DSL comes in various flavors like ADSL (Asymmetric Digital Subscriber Line), VDSL (Very high bit rate DSL). DSL technologies run over copper between the VCO and consumer home. Telco operators use equipment called DSLAM to terminate a fiber connection from the IPTV network and then convert it to electrical towards the consumer home.

Another type of access technology gaining ground is called *FTTH* or *Fiber to the home*. In this technology, the connection between the service provider and the consumer is over fiber using a technology called *PON* (Passive Optical Network). PON has many flavors including APON, EPON and GPON. These three flavors employ ATM, Ethernet and Gigabit Ethernet as the layer 2 framing technology respectively. GPON is probably going to emerge as the dominant design over the long run [29]. GPON offers rates that can exceed 1000 Mbps, a significant quantum leap over existing cable and DSL installations.

3.2.5 Home Network

Consumer home networks typically will work with both telco and cable IPTV platforms. If there is a need for a specific device than the service provider ensures that the customer has it.

In my opinion, the structure of the home network is not a major factor in comparing the two platforms. Hence I am not researching this area in any detail.

3.2.6 Consolidated View.

At this point, the reader is familiar with the major components of the network view. The following diagram provides a snapshot of the entire network [26]:

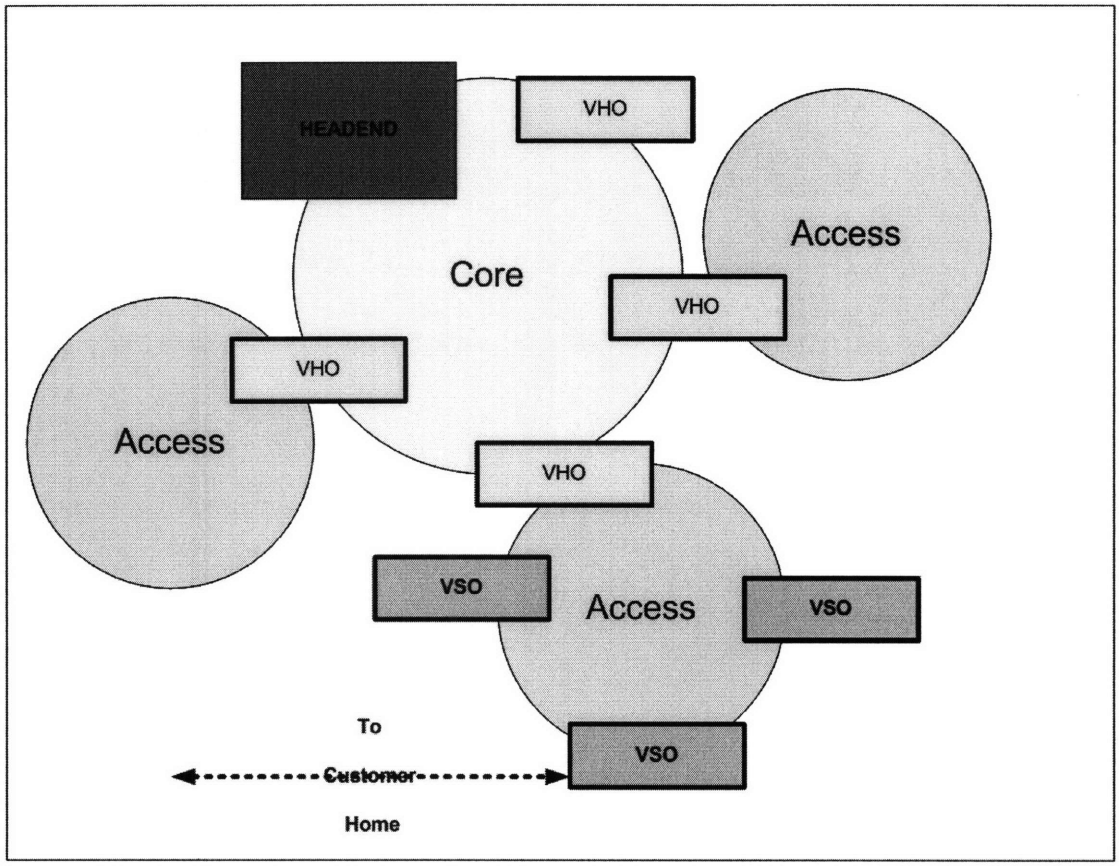

Figure 12: IPTV Architecture [26]

3.3 Functional View

The ITU has provided a functional architecture of a generic IPTV deployment which is reproduced in verbatim below [20]

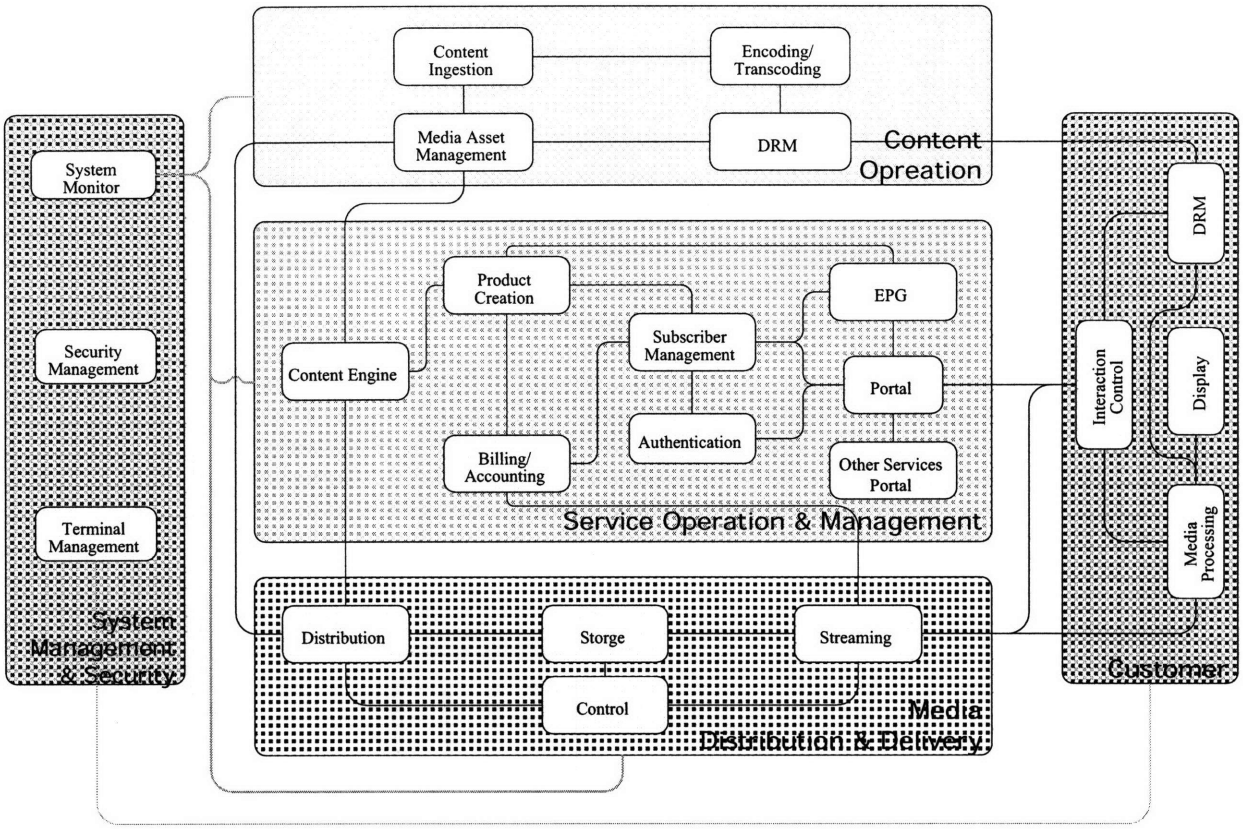

Figure 13: Functional view of Telco IPTV platform [20]

IPTV functions can be divided into the five function sets depicted in the above figure. The *content and operations* function block is perhaps the most critical. It is responsible for delivering IPTV media and IPTV services to subscribers. It has four sub functions. The reader should be familiar with these sub functions as they have been covered in Section 3.2 .

System management and Security function block has three major components. The *System monitor* will locate and triage failures in the system. *Terminal manage*ment is responsible for updating terminals. In my opinion, this module is responsible for install, patch management and updates. It is not clear if the original ITU specification intended to ignore or include these items. Security management is in charge of authentication and monitoring for fair usage. Please note that several of these functions are performed by many network elements, so the capability is actually distributed through the system.

Service operations and management set is responsible for the operational aspect of IPTV outside the content delivery. Its various parts are:

- *Product Creation*
- *Content engine*
    - I believe that these two functional blocks actually belong in the Content Operation set. I am not sure why the ITU choose to re-include them here.
- *Subscriber management*
    - As the name indicated this module will manage the subscribers as well as their subscriptions.
- *Billing and Accounting*
    - Is self explanatory. It would be important to understand that IPTV services sometimes have to be billed in real time. For example, a video on demand movie immediately would hit the customers account. Or if the customer has a prepaid account, the credits available would be depleted immediately.
- *Authentication*
    - Ensures that the customer requesting service is who they say they are, and that they get the services they are entitled to. Subscriber management, billing and authentication are all very closely tied together and there is fair amount of functionality overlap between them.
- *Portal services*
    - Users needing to manage their IPTV services go to a portal to start the process. For example, if a user wants to add a channel to their lineup she would log into the portal and make the request. This concept has become very popular across several industries ranging from brokerage accounts, credit card companies, student services to even dealing with the government!
- *Service Guides*

- Electronic Program guides and related Meta data channels are commonly included here.
-

Media distribution and delivery set is responsible for last mile delivery and has to deal with quality, reliability and service continuity issues in the customer home. The *streaming* part is responsible for content delivery in response to customer input. For example, the customer presses the play button, the movie starts etc. The other components include *control*, *distribution* and *storage*. In my opinion these are covered by content operation and should not be counted again here.

3.4 Telco IPTV deployment

3.4.1 Overview

There have been several telco IPTV deployments over the last 2 years and the technology and services are available to residential and business customers across the globe. In this section I am providing an overview of three important deployments, Verizon, AT&T and PCCW. This is followed by a listing of IPTV services with summary descriptions.

3.4.2 Verizon Deployment

Verizon offers IPTV using FTTP and BPON, with plans to upgrade to GPON in the future. The brand name for this service is *FiOS*. This service has been rolled out in 10 US state sand has signed up 2.4 million customers. FiOS fiber network passed 6.2 million homes and businesses. Verizon has achieved a penetration rate of 14.2% in areas where FiOS is available. Given that the service was launched in 2005, this is a very impressive number. The company expects to see a decline in operational costs related to FiOS

because of automation [27]. Verizon's goal is to get 20 to 25% penetration in five years [16].

I was also able to get a picture of the actual Verizon network architecture is reproduced below in verbatim from source [16].

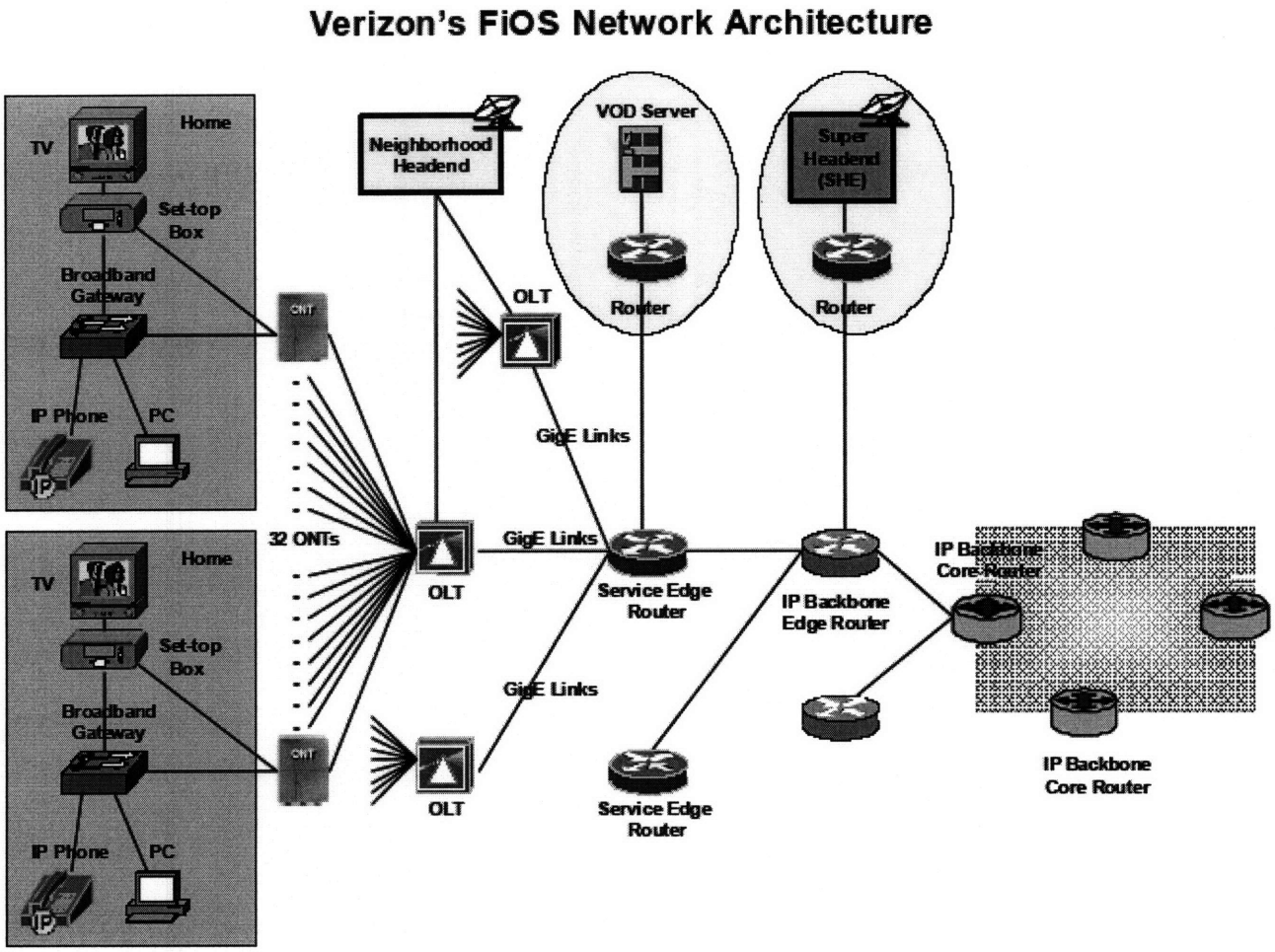

Figure 14: Verizon Network Architecture [16]

3.4.3 AT&T Deployment

In June 2004 AT&T launched project "lightspeed". This initiative was focused on delivering IPTV and related services to business and residential customers. AT&T has

dubbed the package of services as U-verse services. This package is actually a quadruple play of voice, video, data and wireless.

AT&T's approach has been to use FTTN in existing deployments and to deploy FTTP in green field opportunities. They launched IPTV services in 11 markets by end 2006. However the services were not widely available to all customers. Instead they were selectively rolled out to a smaller set. This helped the company work out bugs in billing, back end and content delivery. AT&T plans to have the service made available to 18 Million customers by the end of 2008. AT&T spent $1500 Million on "*Project LightSpeed*" in 2006 and expects to increase expenditure in coming years. Wherever needed, the company made acquisitions to complete Project Light Speed roll out. This further underscores the company's commitment to IPTV.[16][33][34]

AT&T is aware that IP based technologies like IPTV represent a departure from the way they have conducted business. The company is upfront about this and captures it in the annual report. A portion of the annual report representative of this sentiment is capturedin verbatim below:

"The success of our Project Lightspeed broadband initiative will depend on the timing, extent and cost of deployment; the development of attractive and profitable service offerings; the extent to which regulatory, franchise fees and build-out requirements apply to this initiative; and the availability and reliability of the various technologies required to provide such offerings.

The trend in telecommunications technology is to shift from the traditional circuit- and wire-based technology to IP-based technology. IP-based technology can transport voice and data, as well as video, from both wired and wireless networks. IP-based networks also potentially cost less to operate than traditional networks. Our competitors, many of which are newer companies, are deploying this IP-based technology. In order to continue to offer attractive and competitively priced services, we are deploying a new broadband network to offer IP-based

voice, data and video services. Using a new and sophisticated technology on a very large scale entails risks but also presents opportunities to expand service offerings to customers. Should deployment of our network be delayed or costs exceed expected amounts, our margins would be adversely affected and such effects could be material. Should regulatory requirements be different than we anticipated, our deployment could be delayed, perhaps significantly, or limited to only those geographical areas where regulation is not burdensome. In addition, should the delivery of services expected to be deployed on our network be delayed due to technological or regulatory constraints, performance of suppliers, or other reasons, or the cost of providing such services becomes higher than expected, customers may decide to purchase services from our competitors, which would adversely affect our revenues and margins, and such effects could be material [33]"

3.4.4 PCCW deployment

PCCW has been providing IPTV to Hong Kong residents since August 2003. The brand name for the service is *Now TV*. PCCW gives the set top box for free and provides 15 free television channels as well. Customers pay on a per month per channel basis for additional content. Television service is coupled with high speed internet. The customer has significant economic interest to sign up for both Television and internet [16].

3.4.5 NTT Deployment

During the research phase of the thesis effort, I was fortunate enough to have a access to a Vice President at NTT, Mr. Hiromichi Shinohara. Email conversations with him, and data provided by him has enabled me to construct an overview of the FTTH market in Japan.

A unique aspect of the Japanese market is the nature of the competition. In the United States, for a given geography, cable is competing with Telco. In Japan, multiple FTTH

operators seem to be competing with each other, and with ADSL providers. I get the impression that the competition is more vibrant compared to America.

The following figure shows broadband providers in Japan. This information has been copied from the slides made available to me by NTT [73]:

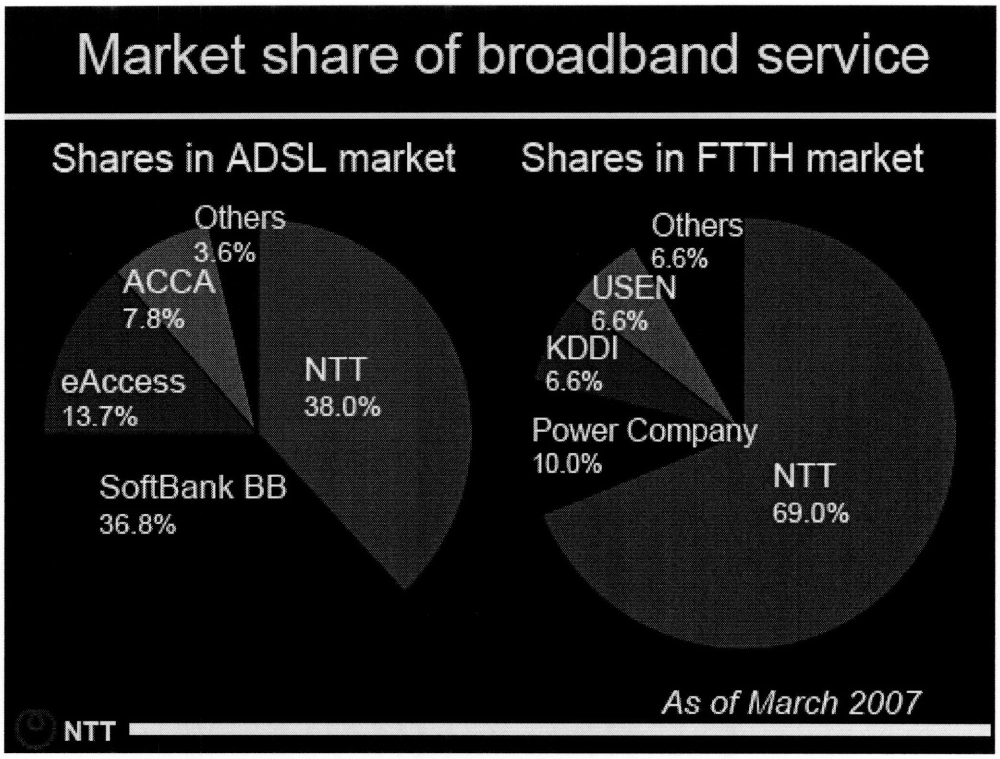

Figure 15: Broadband Market Shares in Japan [73]

Another important feature of the Japanese market is the decline of ADSL and, what seems like the corresponding increase of FTTH. I am tempted to say that ADSL users are switching to FTTH but have not been able to determine that with certainty.

The following figure has been provided to me by NTT and is reproduced in Verbatim:

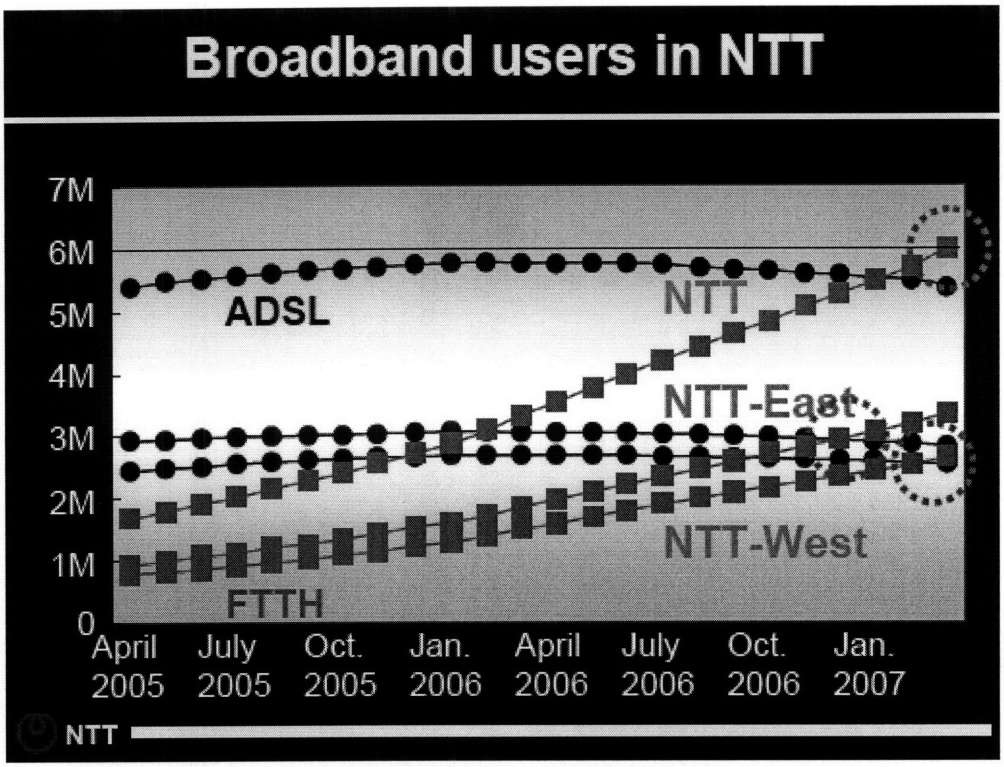

Figure 16: NTT user base, ADSL vs. FTTH [73]

You will notice that the number of FTTH users has been on an upward trend while the number of ADSL users continues to drop.

A June 2007 article from the Journal of Optical Networking provides the following current market figures:

- In December 2006, Japan had more than 7.9 Million FTTH users. [61]. This means that Japan had more than 3 times FTTH users than Verizon FIOS. IN fact, Japan has more FTTH users than the "homes passed" number for Verizon FIOS.
- Increase in number of FTTH users/month is greater than the similar change in ADSL users/month. This has been true since 2005 [61].

The article published in the Journal of Optical Networking suggests that higher speed and higher quality are the key factors behind the explosion of FTTH in the nation. This was

intriguing since I have learned in my research that current application can be easily serviced by access speeds much lower than those FTTH is capable of providing [61].

I suspect that there are two possible factors at play here. First of all, perhaps there was variability in the speeds offered by ADSL that led to customer dissatisfaction. Another factor is superior marketing.

I started thinking about the marketing aspect when I learned about the "*Hikari Dewa*". This term means, Optical phone and is the name for the IP telephony service offered by NTT under its BLFET umbrella. Any student of Electrical Engineering will tell you that phone conversations need very small but dedicated bandwidth. That small chunk of bandwidth can be provided over copper wires also. I think NTT did a good job by associated fiber bandwidth and speed with its telephony service. Calling the phone "optical" was a clever move.

Another startling piece of information was that NTT was offering Satellite Television over its FTTH network [61]. This concept was foreign to me. In America, Satellite TV providers are competing with Cable and Telco and are being relegated to niche segments. In Japan, there seems to be a more symbiotic relationship between at least one telco and satellite company. I shall not be studying this any further but, but this does present an avenue for future research.

Finally data provided by NTT shows that in certain configurations they are providing a 1 Gig/sec pipe to the user [73]. In my opinion this is a major competitive advantage for Telco IPTV platform and I shall discuss this in detail in Chapter 5

Finally, the following figure depicts various NTT services offered to FTTH consumers. Once again, it is provided in verbatim from the data provided by NTT [73]:

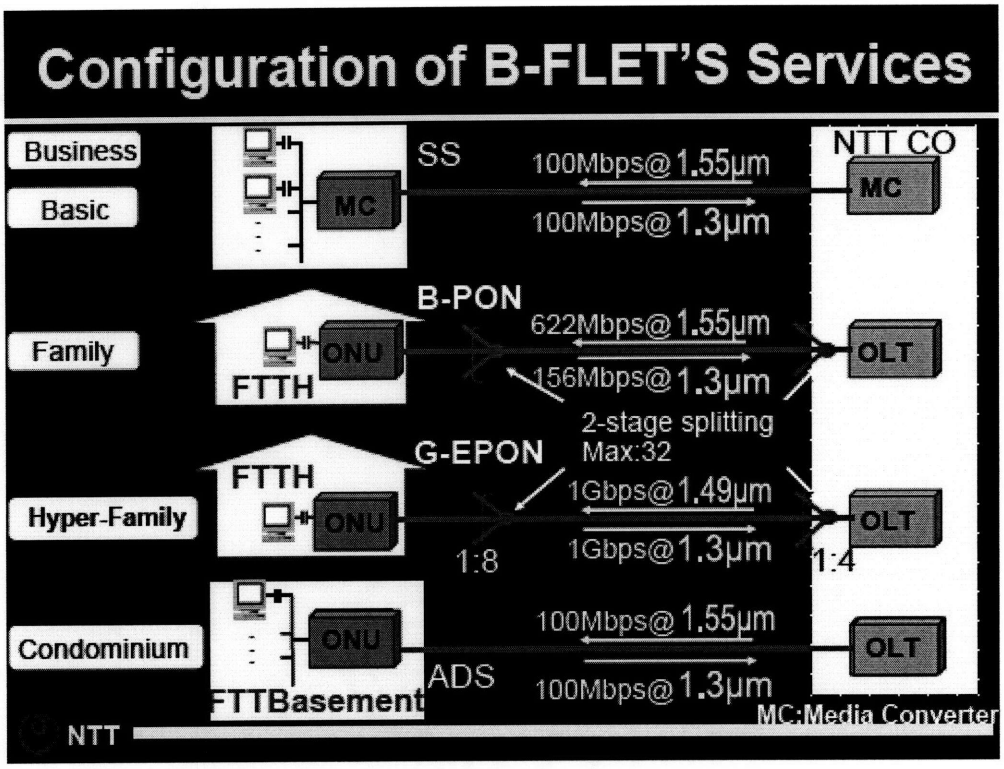

Figure 17: FTTH services provided by NTT [73]

The reader will note that NTT is providing a range of services based on FTTH technology.

3.4.6 Other Deployments

Gartner did a study of leading IPTV deployments in 2005. In this section I am capturing some of that data, primarily companies with a subscriber base of 100K or more. When the study was done, US telcos had not yet rolled out significant IPTV services. Hence the data primarily are focused on non US companies [31].

Carrier	Market	Commercial Subscription to Premium IPTV Services (K)	IPTV users with full infrastructure Set top boxes to receive service (K)	Headend Vendor	DSLAM, FTTX Vendor	Set-top box Vendor	Server Vendor	DRM Vendor
PCCW	China/Hong kong	200	500	Tut Systems, Tandberg	NEC	Yuxing	Entone Technologies	Proprietary
FastWeb	Italy	160	160	Tandberg, Thomson	Siemens, Alcatel, Motorola, Cisco	Own, Telsey, Kreatel, Advanced Digital Broadcast	Kasenna, BitBand	Proprietary
Free	France	160	700	Unknown	Own	Own	Unknown	Unknown
France Telecom	France	142	200	Tandberg	ECI Telecom	Sagem, Thomson	Thales	Viaccess
Telefonica	Spain	120	120	Unknown	Lucent	Kreatel, Advanced Digital Broadcast	C-Cor, Concurrent Computer Corp	Own
Neuf Cegetel	France	50	50	Thomson	Huawei	Netgem	Unknown	Nagra
Manitoba Telecom	Canada	45	45	Unknown	Motorola	Unknown	Sea Change	Unknown
HongKong Broadband	Hongkong	40	110	Unknown	Cisco	Unknown	Unknown	Unknown
Chunghwa Telecom	Taiwan	40	80	Optibase	Alcatel, Samsung, ECI	Pace Micro technology, Acer	Alcatel	WideVine Technologies
KDDI	Japan	80	80	Unknown	Unknown	Unknown	Unknown	Unknown
Sasktel	Canada	40	40	Harmonic	Alcatel, Lucent	Pace Micro	Kasenna	Unknown

Table 7: Major IPTV deployments [31]

Chapter 4 Cable IPTV

Cable companies were already in the business of delivering television programming when the telcos started developing IPTV platforms. The cable response started with an effort called *NGNA*. This effort is described in the next section. After that, this chapter explores some specific and targeted aspects of cable architecture. Cable and telco primarily differ in the access part of their networks. Hence a significant part of this chapter is devoted to that discussion.

4.1 Cable Strikes back

In spring 2004, the nations top three cable companies, Cox, Comcast and Time Warner issued a RFI (Request for Information). This document was distributed to about 120 companies. The key takeaway from the document was that cable companies were attempting to migrate from a hybrid analog/digital platform to an IP protocol based, all digital platform.

As we have learned earlier in this thesis, an all digital architecture is a "must have" for providing IPTV services. The RFI process was managed, in part, by a Lexington based company, PDS consulting. While researching this subject I conversed with Peter Shapiro, a principal at the firm about the above mentioned RFI process

Peter told me that this entire effort was dubbed *Next Generation Network Architecture (NGNA)* initiative. The NGNA effort is leading to a new architecture for the cable platform. This improved platform makes it possible for cable providers to deliver IPTV and the related set of services.

NGNA was successful. However information about the effort was difficult to find. I asked Peter about the secrecy surrounding the effort. He wrote back to me and explained, "The NGNA project was intended to indicate to equipment suppliers and other stakeholders how the major MSOs were thinking of evolving their networks. Substantive information about NGNA was provided to vendors and others under non-disclosure agreements, which is why it is difficult to find such info in the public record.

That being said, I don't think you need to get the details on NGNA in order to compare cable network architecture to IPTV. There is a lot of public info on this topic and if you can talk with a cable engineer (which I am not), you can fill in what you are unable to find in print. You may also find useful info from some of the technical panels at the NCTA and SCTE shows, and on the CableLabs website (www.cablelabs.com)."

In fact, a LLC called NGNA LLC was created to manage the project!

CED magazine in a May 2004 article proclaimed the following: "Call it Cable's loudest secret. Everyone worth their technical salt knows something about it, yet the MSOs behind it are not in the mood to discuss it publicly"

The article notes that the cable companies had already put in some work in defining the architecture. They wanted to rapidly drive consensus to reach the definition of a next generation platform.

Interestingly, a similar secret approach was also used in the early 90s to design DOCSIS based access networks. That project was called *Multimedia Cable Network System (MCNS)* [41].

4.2 Architecture definition process

As I mentioned before, the NGNA architecture process was a very controlled process. NGNA LLC and Cable labs represent a semi-open environment, heavily controlled and orchestrated by US cable providers. Participation in cablelabs standards efforts is not open to everyone. One needs to be in the "Cable Orbit" to be able to participate. I am one of the authors of the packet cable specification put out by cablelabs and I can speak from experience on this subject.

NGNA architecture attempted to fix the following:

- Move from a circuit switched architecture to a packet switched architecture.
    - This results in bandwidth savings, opex savings and capex savings. It also allows higher utilization of bandwidth and resources.
- Data, Voice and Video flow over a common IP based digital network to the edge of the cable network.
- Make it easy to deploy new services.

Let me elaborate on the business advantage of a packet switched digital network. In such a network, since the equipment essentially sees bits and bytes, the same equipment can handle multiple traffic streams, for various services. This reduces cost to create, upgrade, maintain and operate the network. Also, statistical techniques can be used to overprovision. All this is possible only in packet based networks.

4.3 Cable Architecture

In section 3.1, I discussed at length the six views needed to analyze the architecture of a system. There is no value in repeating that again. In the next section, I will describe the form/network view of the NGNA inspired cable architecture.

4.4 Network view

4.4.1 Overview

Cable network view is remarkably similar to that of Telco IPTV network view. The network has three major parts:

- Main headend part which receives programming. This can serve up to a million homes. This is similar to the Telco headend and performs similar functions [44].
- Next leg of the network comprises a series of primary hubs connected by high speed fiber. Hub connections have redundancy built into them. A primary hub can serve up to 100k customers. The primary hubs are further connected to small number of secondary hubs. Each secondary hub serves about 20k customers. The secondary hubs form a hub and spoke arrangement with the primary. The hub (in the hub and spoke) is the primary-hub while the spokes are the secondary hubs. Connections from the primary to the secondary hubs are via high speed fiber. This part of the network also resembles the telco core network [44].
- Every secondary hub is connected to about 10 to 40 modes via a fiber link. Every node serves 500 to 2000 homes. Nodes are connected to homes using coaxial cable. Note that this connection is not fiber. This part of the network corresponds to the Access network of Telco IPTV [44].

The access network is where the big differences between telco and cable surface. Since various telco offerings differ from each other in the access network, I am choosing Verizon FIOS as the comparison candidate with cable. I would like to highlight the following differences:

- The "last mile" in telco is fiber while in cable it is coaxial cable. Perhaps, this is a great opportunity to introduce the term *Hybrid Fiber/Coax (HFC)*. The node terminates a fiber link from the secondary hub. The last mile is a coaxial cable running RF signal. The astute reader will note that this arrangement is very similar to FTTC in the telco network. The protocol running between the consumer

home and mode is called *DOCSIS*. The new architecture uses a version called *DOCSIS 3.0*, which is described in a public standard [36][38][39].

- Cable last mile is a broadcast environment while telco is a switched environment [46].

I shall elaborate on the above bullet a little more. We will have to understand some basic networking constructs to appreciate this. In networking a popular topology is called the *star topology* and is shown below:

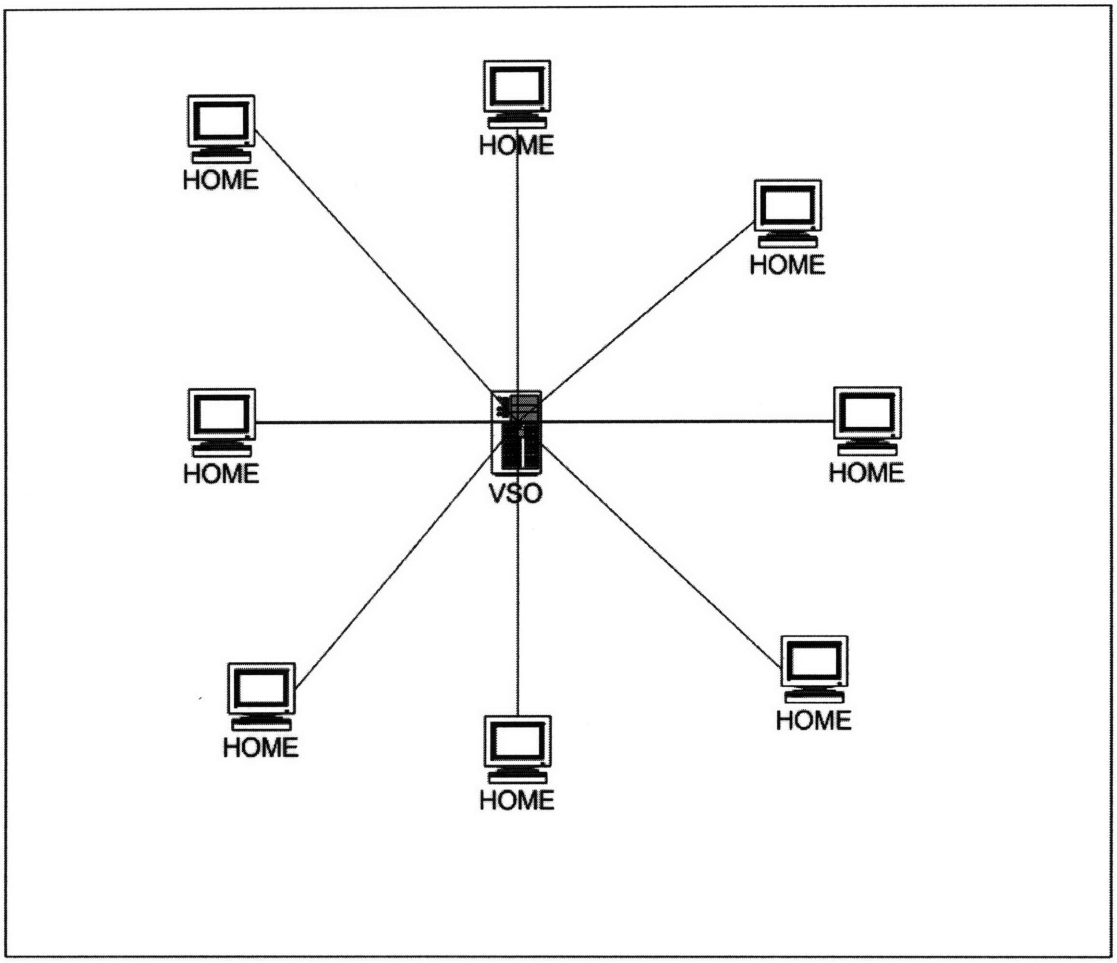

Figure 18: A Star topology

In this network, each end device connects to a central node or hub. This is how the access network for telco is designed. The VSO connects with the consumer using a star

connection. Communication from the VSO to a given consumer node is not seen by other nodes.

Cable access architecture uses a different topology, called the bus topology. All nodes/devices are connected to one central communication channel called the bus [36] [46]. In a bus architecture, the message is sent on the bus, and every device sees the message. However, only the device for which the message is destined, consumes it.

Bus topology is represented in the figure below:

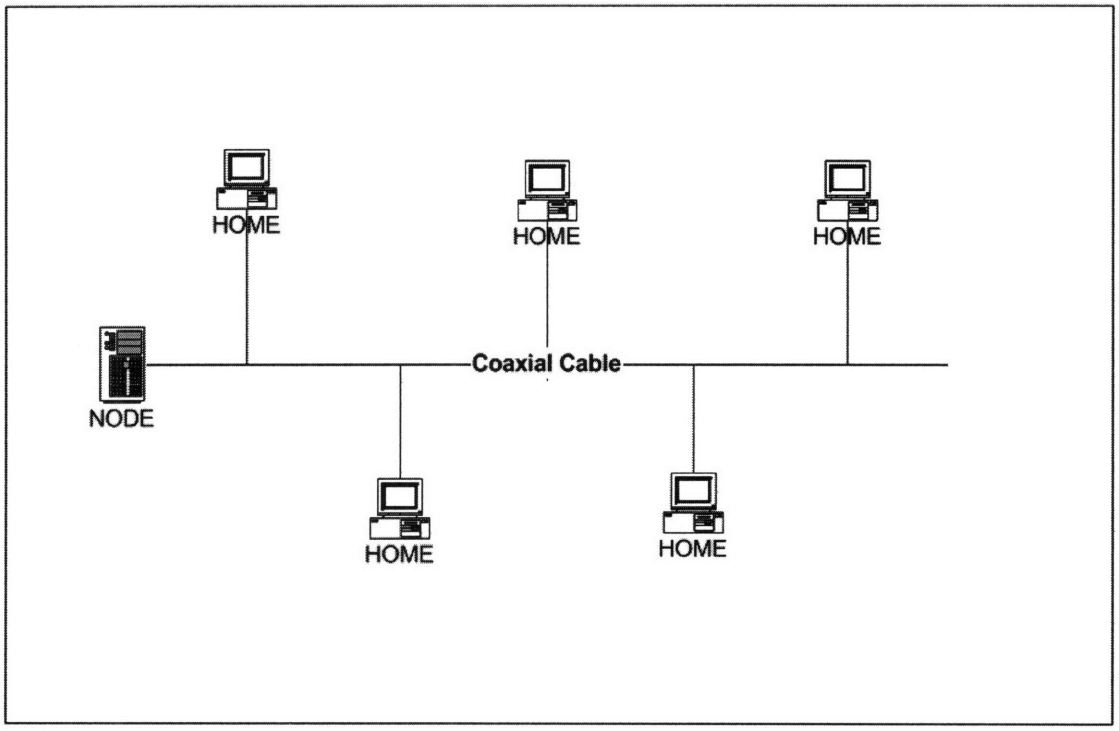

Figure 19: Bus Topology

4.4.2 Component View

As I have mentioned before, there is a significant overlap in the architectures of cable and telco. I have briefly described the differences in the access network and will describe cable access in more detail soon.

During the research phase of my thesis, I conversed with a senior video systems architect at Cisco. They are a key supplier to cable companies. In fall 2006, Cisco made a presentation to an IEEE meeting, describing next generation architecture and technologies. I am reproducing in verbatim the cable architecture diagram put together by Cisco. I believe this architecture is representative of actual deployments and have provided it below [47]:

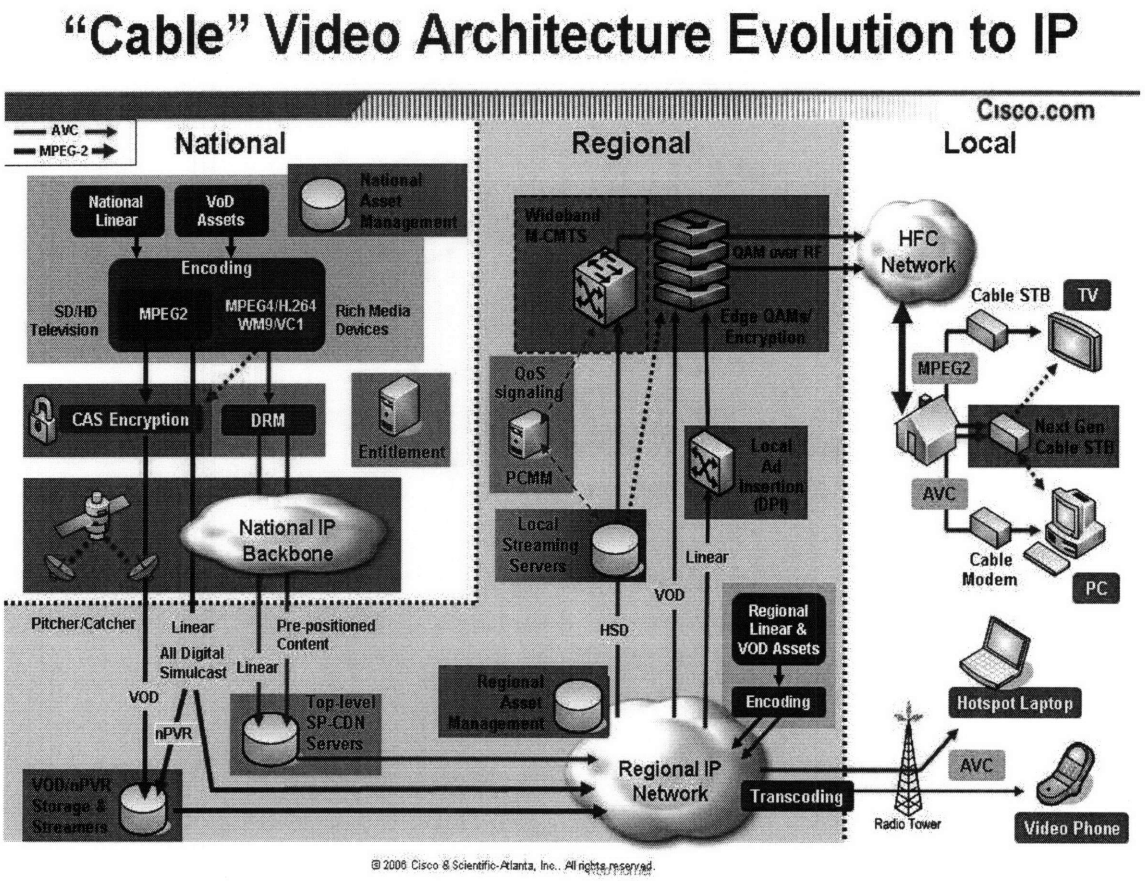

Figure 20: Cable Architecture [47]

The above diagram is self explanatory though I will take the opportunity to describe some of the new components that the reader my not be familiar with.

- AVC. AVC or MPEG 4 Advanced Video Coding is a cutting edge encoding standard developed by the ISO and ITU. It is widely deployed in several video

solutions. The coding standard is reported to provide DVD quality images over a DSL line [53]

- MPEG2: MPEG 2 is a popular video codec that is widely used today. It predates AVC [54]
- CAS Encryption: Conditional access systems or CAS provide the ability to encrypt programming such that only authorized users have the ability to de-crypt and view the program.
- nPVR: A PVR is a Personal Video Recorder, example would be Tivo. It lets the user record programming and then view it at her convenience. When someone records programming they need disk space to store it. The nPVR is a PVR variant which provides the storage on a network. Hence nPVR would be network PVR [55].
- M-CMTS: The M-CMTS is an integral part of the next generation access network. The acronym stands for Modular Cable Modem Termination System. Section 4.4.3 describes this device in detail [40]
- PCMM: Packet Cable Multimedia is a technology that lets cable providers offer phone services. The technology is based on a popular internet technology called SIP or Session Initiation protocol [56].

I would like to highlight the following key takeaways from this diagram:

- M-CMTS plays a critical role in reducing operating expense and capital expense. It also enables higher bandwidth utilization.
- Network diagram shown previously hints at a wireless component. There is ongoing work at cablelabs to bring wireless technologies into cable services. Some of this work is being done under the IMS umbrella. However this subject is beyond the scope of this research.

4.4.3 Access Network

Traditionally a device called the *Cable Modem Termination System (CMTS)* was present in the access part of the network. This device provided data (internet access) and voice (telephony) capabilities.

In the new NGNA based architecture the CMTS provides video/TV services as well. The CMTS has changed significantly. It is now called M-CMTS or the decoupled CMTS.
The architectural details of the M-CMTS are described in specifications and white papers [40] [48] and are summarized in this section.

Description of the M CMTS

In the following figure presents a network view of the MCMTS. It is provided in verbatim from a Motorola white paper [40]:

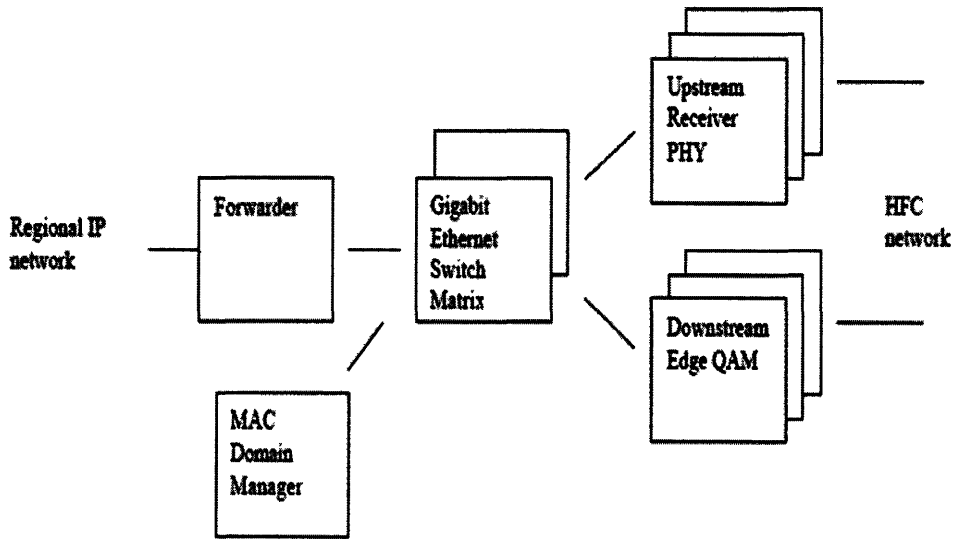

Figure 21: M CMTS Architecture [40]

The module labeled *Upstream Receiver PHY* is responsible for providing a communication channel from the consumers home back to the cable service providers own network. In cable parlance this direction is referred to as *Upstream Direction* or simply *Upstream*.

The module labeled *Downstream Edge QAM* is responsible for creating a communication channel in the other direction, towards the consumer home. This direction is often referred to as the *Downstream direction* or simply *Downstream*. Please also note that the edge QAM is a variant of video QAM device traditionally used for delivering video on demand.

The *Forwarder* component is the interface between the core network and the HFC network. *MAC Domain Manager* implements the control plane. This means that it is responsible for setting up and maintaining sessions.

I have noted previously that all types of traffic, voice, video and data flow through these channels. However, each traffic type has different bandwidth and quality of service requirements. Telephony needs very little bandwidth, but capacity needs to be reserved in both directions, upstream and downstream.

Video needs high level of dedicated bandwidth in the downstream direction, but not in the upstream path. Data is bursty in nature and needs high bandwidth for small time frames.

The implication for MCMTS components is obvious. The devices need to have intelligence to be able to detect and then treat different types of data types differently.

Before I close out this section, I will also provide a logical diagram of the M-CMTS as published in the standard. The standard notes that the diagram is "informational",

however several detailed technical aspects of the interfaces are well defined. Next figure is copied from the above mentioned cable labs specification [48]:

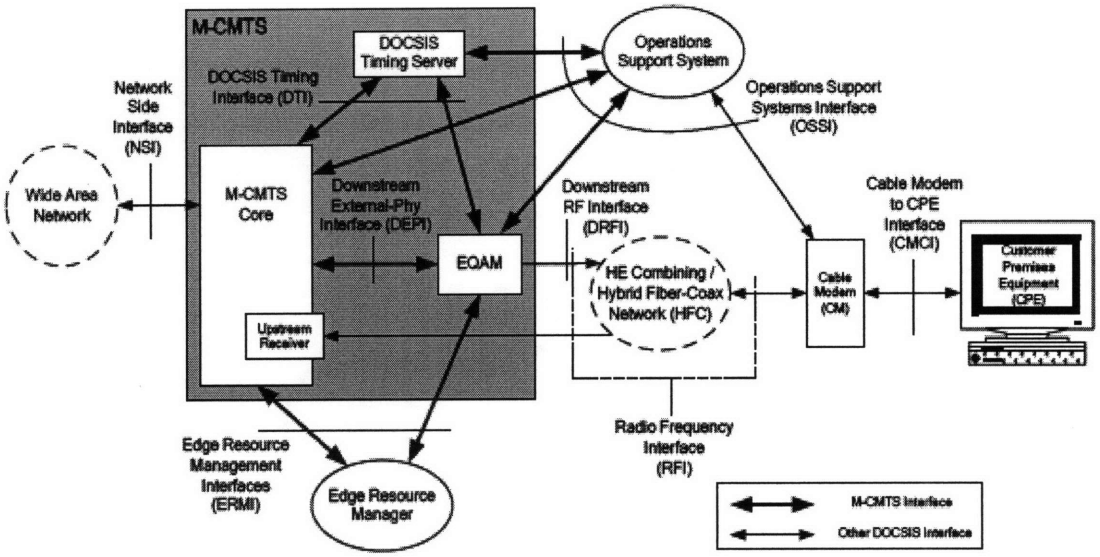

Figure 22: M CMTS Architecture [48]

4.5 Deployments

The top three cable companies, Cox, Comcast and Time Warner all offer data, video and telephony services. They are all either upgrading to DOCSIS 3.0 or are considering upgrading to DOCSIS 3.0.

I read the annual reports of both Comcast and Time Warner. Neither company mentions either IPTV or DOCSIS 3.0 in the annual report [57] [58]. This makes it very difficult to gather any useful information about deployments.

Chapter 5
Platform Comparision

I begin this chapter by analyzing N sided platforms and attempting to predict if the market will allow for both platforms to coexist?

Later in this chapter I highlight significant comparison points between the two platforms. These data points became evident to me during the research captured in the previous two chapters.

Towards the end, this chapter also discusses a high level comparison framework which is derived from published work by Meyer and Lehnerd [3]. I will apply the framework to both platforms and then attempt to isolate any significant differences.

5.1 Is this a winner take all market?

5.1.1 Introduction to multisided platform.

Several business authors have written about multisided platforms. In October 2006, Harvard Business Review published an article which described business strategies for two sided platforms [66]. Some of these strategies apply to N sided platforms, where N > 2.

A working paper by Hagiu recognizes the concept of platforms with more than two sides and calls them *Multi Sided Platforms* [65].

We established in chapter 1 that the telco and cable platforms were 3 sided platforms. Earlier in the thesis I coined the term *Mega-Platforms* to describe the telco and cable offerings. I shall now build upon that and call it *Multi Faceted Mega Platform* or *MFMP* for the rest of this document.

In this section, I would like to evoke some of the concepts described in published literature on MSPs, and apply them to our MFMPs. As part of the process, I will analyze various axioms from the paper and determine if they apply or do not apply to our systems. At the end I shall attempt to answer the following question:

Are the business dynamics such that one platform will emerge victorious? Alternatively will the two platforms coexist?

Please note that in this case, I am NOT trying to answer the question of, "Which side will win?" That will come later.

In the Eisenmann article the authors use a very simplistic definition of platform. In the article, the authors note, "Products and Service that bring together groups or users in a two sided networks are platforms" [63].

This is a very basic definition and I am using a more complex definition for this research. Also, the article is confined to 2 sided markets only. Our market is three sided, perhaps four sided if you were to count user generated content as a separate side.

In a MFP, we can divide the stakeholders into two broad camps:

- Subsidy side users
- Money side users.

Money side users, as the name implies, are willing to spend money. On the other hand, subsidy side users are less willing to spend money. Sometimes increasing the number of

subsidy side users makes the platform more attractive to the money side users. This provides an incentive to the platform owner to subsidize the subsidy side user.

In our case, none of the stakeholders readily fit the definition of subsidy side. Perhaps we cannot conclude that every mutlti-sided platform needs to have a subsidy side. One important difference here is that the various users have ways of bypassing the platforms. Content providers can directly reach the customer by offering programming on alternative vehicles. One can watch the entire Sopranos on DVD and bypass HBO/Cable/FIOS altogether!

MFPs provide economic value add by performing the following two functions well [65]:

- Reduces Search costs
- Reduces shared costs after the search.

Reducing search cost refers to providing a convenient vehicle for the various parties to discover each other. Once the producers and consumers have connected, the presence of the platform reduces the cost of business. Telco and Cable platforms both perform these functions well.

5.1.2 Is winner take all dynamics at play?

In a market where multiple N sided platforms are competing, certain factors make it more likely for a single platform solution, while others foster an environment where several platforms can coexist.

Multi-homing

Let us first start by understanding the term *Multi-homing*. This expression refers to the concept of a user engaging with multiple platforms. If the cost of multi-homing is high, the system tends to favor a winner all steady state [66].

IPTV stakeholders are often players on multiple platforms simultaneously. Advertisers and content providers are working with both telco and cable service providers. Consumers sometimes have services from both. Even when they have service from one entity only, it is easy for them to switch. However many users do not switch because of "inertia", and will switch only of there is a compelling reason. Form the perspective of multi-homing, it appears that the system will let multiple platforms coexist.

Positive Network Effects

Network effects arise when the adoption of a product or service by the N+1th consumer increases the value of the goods and services for the other N consumers [64]. When network effects start to dominate, the system tends to favor a single product or platform. For example, when I start using MS word, it increases the value of MS word to existing users. If this becomes a trend, eventually everyone shall be using MS word.

Now let us think of examples from the research subject. Does it really matter (from the perspective of network effects) if my telephone provider is Verizon or Comcast or if I have a cell phone? If you have Comcast phone, does your phone become valuable if I switch phone service to Comcast? Do existing subscribers to Verizon TV get a better viewing experience if I switch from terrestrial broadcast to FIOS? The answer to all these questions is NO.

In general, since both telco and cable are providing similar service, is there a strong reason for users to have a preference for one over the other? Again the answer is NO. The services and price structure are very similar.

Hence, I can conclude that Networks effects will favor a system where telco and cable can coexist.

Positive Indirect network effects

The concept of network effects is applicable to both traditional platforms and to MFMPs. Indirect network effects are unique to multi sided platforms.

If an increase in one type of user makes the platform more attractive to the other type of user, we can say that Indirect network effects are at play, and are positive. Mangers wanting to increase revenue and profit footprints should use indirect network effects as a key tool [66].

In the cable/telco environment, these effects are omnipresent. An increase in the number of consumers will make the platform more attractive to content providers and advertisers. Similarly, increased content makes consumers more likely to sign up for service.

An important side effect of this factor is that platform captains will try to provide newer services to gain more users, thus reinforcing indirect network effects. Traditionally the cable platform provided television service and now it provides voice, video and data. Similarly cell phones have evolved from being a phone to a phone, camera, camcorder and PDA, all in one.

Hagiu has termed such an expansion an "imperialistic expansion into adjacent markets" [66]. While I am not thrilled by the phrase, I agree that MFMP can reinforce and grow indirect network effects by such expansion. The caveat, though is that this expansion will bring them in competition with companies from new industries. One way to mitigate the risk is to partner with a company from the new industry. This has the obvious disadvantage of limiting profit potential.

Threat of envelopment [63]

Envelopment refers to a situation where a platform is taken over by a complementary platform. If both cable and telco were to be enveloped by a new player, than we will have a single platform situation.

I believe that, threat of envelopment does not currently exist. On the other hand, the ability to provide wireless services will augment telco/cable platforms. We may witness them enveloping a wireless platform. I suspect that the telcos have a slight advantage here because they have existing presence in the wireless industry.

I infer that this industry is set up to allow the coexistence of both platforms. In the next sections I will attempt to understand if one of the platforms has an advantage over the other. Further, I will explore if that advantage could be built into a tipping point.

5.2 Platform Comparison: New Levers

An informed reader will probably agree with my statement that the cable and telco platforms are remarkably similar. I have demonstrated the similarity in the architecture sections. Further, the business models are very similar.

In this section I will discuss specific areas where comparison between the two platforms might provide insights into competitive advantage.

These new comparison points are actually brand new "Levers". In chapter 2 I introduced the reader to the concept of platform levers conceptualized by Gawer and Cusumano [1]. I am extending that concept to introduce the following new and differentiated levers:

- Lever 1: Technological Superiority.
- Lever 2: Excessive Capital Investment.
- Lever 3: Ability to deal with disruption.
- Lever 4: Ability to manage ecosystem relationships and evolution.[1]

[1] A few readers have pointed out that lever 4, actually enjoys a fair degree of overlap with one of te levers developed by Gawer and Cusumano. I accept that to be true.

In this section we will discuss what each lever means, compare the two platforms and then potentially answer the following question:

- ***Does one of the platforms have an inherent advantage that will tip the market in its favor?***

5.2.1 Lever 1: Technological superiority.

Does the consumer really need bandwidth provided by Telco FTTH based IPTV?

The access network is very different for the two platforms. In fact, even within the telco world, the access network architecture varies from company to company. The Verizon and NTT architecture of FTTH represents the most advanced incarnation. I shall use that as a reference point.

Fiber to the home technology can provide bandwidth of up to 1 Gigabit/second while Cable technologies are limited to 200Mbps[43][49].

FTTH based solutions promise to provide a Gigabit Pipe into the customers' home. I am asserting that the higher bandwidth makes FTTH solutions technologically superior. For the sake of completeness I will also mention that current US FIOS deployments are no where close to providing 1 Gig of bandwidth [60]. However as the technology and software improves, I believe higher bandwidth deployments will become possible.[2]

Let us assume that my assertion that one platform is superior is true. This assumption engenders the next few questions:

[2] At least one industry expert has commented that the the Cable companies can overcome the bandwidth issue by a DOCSIS 3.0 technology called channel bonding. They may not reach the absolute values delivered by cable but would deliver enough bandwidth to be competitive.

- Does technological superiority entail that one platform can exclusively satisfy a set of customer needs?
- Does the customer really need that much bandwidth at her disposal?
- Does this represent a potential tipping point?

The business question Engineers at Harmonic have put together a white paper describing how IPTV related services can be provided over a VDS2L line running at 20Mb/s. They have described 4 scenarios of service offerings that can be fit in the VDSL pipe. Please refer to the appendix if you want to learn more about Personal vide recorder (PVR) services. The four deployment scenarios are captured below [17]:

Scenario		**TV1**	**TV2(SD)**	**TV2 (HD)**	**High speed internet**	**Voice service**	**UI**	**Total Bandwidth**
1	Service	Live	VOD	N/A	Broadband Internet	Three Telephone lines	4 PIPs	
	Bandwidth	1.5 Mbps	1.5 Mbps		6 Mbps	0.2 Mbps	0.4 Mbps	9.6 Mbps

Scenario		TV1	TV2(SD)	TV2 (HD)	High speed internet	Voice service	UI	Total Bandwidth
2	Service	Live	VOD	Live	Broadband Internet	Three Telephone lines	4 PIPs	
	Bandwidth	1.5 Mbps	1.5 Mbps	6 Mbps	6 Mbps	0.2 Mbps	0.4 Mbps	15.6 Mbps
3	Service	Live	PVR	Live	Broadband Internet	Three Telephone lines	4 PIPs	
	Bandwidth	1.5 Mbps	3 Mbps	6 Mbps	6 Mbps	0.2 Mbps	0.4 Mbps	17,1 Mbps

Scenario		TV1	TV2(SD)	TV2 (HD)	High speed internet	Voice service	UI	Total Bandwidth
4	Service	Live	N/A	PVR	Broadband Internet	Three Telephone lines	4 PIPs	
	Bandwidth	1.5 Mbps		12 Mbps	6 Mbps	0.2 Mbps	0.4 Mbps	20.1 Mbps

Table 8: IPTV Use cases with VDSL2 network to consumer home [17]

The simple answer is no. Current IPTV offerings do not need that kind of bandwidth. Cable and DSL can deliver similar services at lower connection speeds in the access network.[3]

However, if a new killer application emerges in the future, FTTH based deployments will be able to take advantage of it while other technologies may face difficulty in adapting.

[3] Please refer to my interview with Mr. Wai Shun Lo of HBS in the appendix. He also suggested that the excessive bandwidth does not translate into an immediate competitive advantage.

Finally, DSL availability can be limited because of distance from the CO and quality of coax. Fiber does not have these problems.

A key recommendation from this finding is that Verizon should be focused on figuring out how to fill the access pipe. Are there new applications out there that will drive bandwidth demand? If the capacity to a customers' home ever becomes a limiting factor for the cable consumer, Verizon would enjoy a significant business advantage.

AT&T should also be doing the same. While their model is primarily focusing on fiber to the node, they are actually deploying FTTH in green field areas[33]. Telecommunication scientists have also opined that upgrading from FTTN to FTTH is economically and technologically viable [35]. It appears that AT&T is using a real option technique and will probably upgrade from FTTN to FTTH when the need arises. Verizon on the other hand is providing the complete solution from the beginning.

Before I conclude this section, I would also like to bring to the readers attention some research which seems to indicate that excessive bandwidth in the access network is not really needed, though I am not convinced that the research is relevant as-is.

Perhaps you have been in a situation where time seems to go faster than it really does. You are having a nice time and before you know a whole hour passes. Essentially, reality and perception are diverging. Proponents of cable are very fond of quoting research from AT&T to downplay the importance of high bandwidth. I came across this research several times during my studies and hence I feel I should discuss it a bit.

Researchers at AT&T Labs have coined a term called *Equivalent Circuit rate or ECR*/ This is the bandwidth corresponding to what the user is experiencing. For example, the user may have a connection of K Mbps but based on how her applications are responding she thinks she had a connection of L Mbps. If $K < L$, then that is bad news for the FTTH proponents!

The researchers found that 31Mbps shared HFC channel was able to support 650 users, each engaged in active web browsing at 37 kbps. The ECR was 6 Mbps. These results were derived from a simulation experiment [32].

The explanation was very simple. Web browsing has long periods of "inactivity" at the communication layer. Thus all users, though online and browsing at the same time, are not using the channel simultaneously.

There are some issues here that we should discuss. The experiment was conducted in 2001 and internet usage, gaming and multimedia applications have evolved since then. When someone is watching television the connection pipe is utilized. Unlike web browsing, which generates bursty traffic, television streaming towards the user has constant bandwidth usage.

I asked one the authors of the original study for their perspective on this. I am happy to report that the researcher believes that my comments have merit. An interested reader can find the email thread in Appendix titled "Conversations with ATT Researcher".

Is there a tipping point from high speeds?

It is clear that telco has a large advantage here. They provide higher speed in the access network. It is also clear that current, mainstream applications will work well with the lower cable access speeds.

A tipping will occur if the telco companies are able to sponsor creation of new applications/services that work well only with access speeds, higher than what cable provides.

5.2.2 Lever 2: Higher investment levels.

Will capital investments levels play a key role in deciding who wins?

I will start this section by establishing two points which will be proven later in the section.

- Current market deployments numbers in the US are low for both sides, though one platform has higher deployment levels.
- Investment is higher in one platform.

Does this imply that one side has an advantage?[4]

Deployments.

In 2006, Gartner published a research report profiling several infrastructure technologies, their adoption potential and so on. The report covered both DOCSIS 3.0 as well as FTTx. The following table summarizes the differences between the two technologies as provided in the report [49]:

Factor	DOCSIS 3.0 in the consumer home	FTTx
Market Penetration	Less than 1% of target	Between 1% and 5% of target

[4] While discussing this lever with Dr. Cusumano, he pointed out that being able to deliver a new platform technology with less investment would be a competitive advantage.

In light of this discussion, I must clarify this lever a little bit. When I am focusing on excessive investment, I am by proxy referring to development of excessive features, products, services that soak up the excessive capital. I am assuming that capital is being spent judiciously and wisely. This lever is NOT about splurging money.

Factor	**DOCSIS 3.0 in the consumer home**	**FTTx**
Target Markets	Residence, Small and Medium business	Residence, Small and Medium business
Adoption Speed	Final version of the specification was released in May 2007. Vendors are currently shipping pre DOCSIS 3.0 products. These products incorporate significant chunks of DOCSIS 3.0 functionality and represent smart moves to kick start adoption.	The technology is in deployment in South Korea, Japan and parts of North America. The specification is still being worked upon but seems to have stabilized. I expect the spec to continue to evolve and improve.
Competing technologies	ADSL variants, VDSL, FTTx	DOCSIS 3.0, ADSL and VDSL
Key Vendors	Ambit Arris Cisco Motoroal	Cisco Huawei Tellabs

Table 9: FTTX vs. DOCSIS 3.0 [49]

While both Cable and telco have made significant inroads with this new technology in several places, I was surprised to see that most of the target market is still untapped. Obviously, we are not dealing with green field opportunities here. Hence adoption will be at the expense of other solutions, sometimes even cannibalizing one's own solution.

I have trouble believing the 1% to 5% penetration number, as they seem low to me. Since the report did not provide details on how they derived the number I am unsure how to process it further.

For example, cable companies may be deploying DOCSIS 3.0 functionality without having the customer upgrade to new cable modems. The report looks at DOCSIS 3.0 adoption form the perspective of shipment/deployment of DOCSIS 3.0 cable modems. In fact, BigBand networks claims in its marketing material that its MCMTS can provide higher access speeds without making the customer upgrade to a newer modem [50].

For the current research effort, I am happy to assume that both technologies have a long way to go before they gain large scale acceptance.

Investments

In this situation, capital investment and R&D dollars may influence which side will win. Research at Morgan Keegan and company indicate that the Telcos are outspending the cable companies. In the following figure, reproduced in verbatim from published literature, the trend is obvious [43]

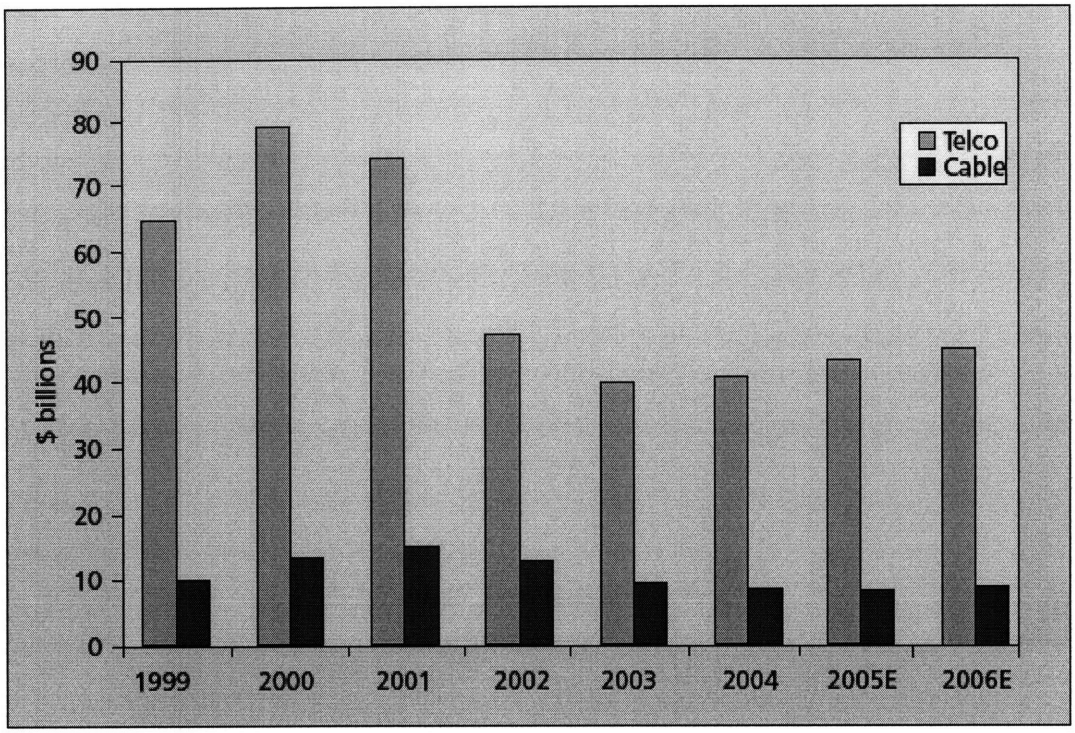

Figure 23: Telco vs. Cable Capex [43]

Since the telcos are outspending the cable companies, can I assume that they will have an advantage? Unfortunately, it is not that simple. Cable solution is evolutionary and builds upon a previous generation. The telco solution is more revolutionary, so perhaps is more expensive.

Is there a tipping point from investment levels?

Telcos have a slight advantage since they have a head-start and are investing more money. However it is possible that the higher investment level is a function of more expensive technology. It is also possible that the higher deployment levels are at the expense of DSL lines and not cable.

While discussing this lever with Dr. Cusumano, he pointed out that being able to deliver a new platform technology with less investment would be a competitive advantage.

In light of this discussion, I must clarify this lever a little bit. When I am focusing on excessive investment, I am by proxy referring to development of features, products, services that soak up the excessive capital. I am assuming that capital is being spent judiciously and wisely.

In summary, I will say Telcos have a slight advantage.

5.2.3 Lever 3: Ability to deal with disruptions.

Is 'wireless access' a disruptive force? How are the platform leaders dealing with it?

It is very difficult to predict disruptive technologies and business models. In the Innovator's Dilemma the author acknowledges it is very difficult to predict and to deal with disruption [56].

This lever does not lend itself to easy comparison. It is not trivial to predict which platform is more suited for dealing with disruption because one does not know what the disruption is going to be!

In this section I will supply one of the missing parameters, the disruptive force. Mesh Wifi access is potentially a disruptive force for both cable and telco. Which platform is better set up to deal with it?

The disruptive force

While I am trying to figure out whether the Cable or the Telco platform shall dominate, there is another important platform emerging. This platform, in its current incarnation provides wireless based internet access using wifi mesh technology.

A graduate student at MIT, Mudhafar Hassan-Ali, wrote a thesis on this subject. He studied deployments in California and Massachusetts where local government provided internet access using *Wifi Mesh* technology. Mr. Hassan-Ali, is very optimistic about the long term prospects of this technology. However some of the research referenced in his thesis indicated that several experts were less optimistic [51].

In any case, the wireless platform represents a significant force that needs to be considered in the telco and cable battle. Both telco and cable, provide a "pipe" into the consumers home. However, they do not want to be infrastructure providers only, they want the consumer to get all services from them.

Let me illustrate this with an example. If a consumer signs up for Comcast data service, but gets their phone service through Vonage, it puts Comcast in a disadvantageous situation. They would rather have the user sign up for Comcast telephony instead. When she gets telephony service from Vonage, she is reducing the cable company to a *simple infrastructure provider* and the cable company does not want to be in that business.

Now we have a situation where a new player (Municipal Wifi) emerges whose business model is to be a simple infrastructure provider! Cable and telco players will need to rethink their business models to provide service in such an environment. Currently they provide infrastructure and service. Can they make money providing services over someone else's infrastructure?

In summary, wifi mesh providers are in the business of providing infrastructure channels only. Cable and telco do NOT want to be in the infrastructure business. They want to sell the connection infrastructure and also services on top of the infrastructure. The wifi providers represent a new business paradigm which could disrupt the telco/cable providers. Please note that the disruptive force is the business model (followed by wifi mesh providers) and not necessarily the technology itself.

Is there a tipping point resulting from WiFi?

There isn't one yet, but Wifi represents a potential opportunity for cable/telco.

If municipal wireless becomes successful, a tipping point for the cable/telco battle could be reached. Whichever side devices a profitable business proposition, including (or collaborating with) mesh WiFi (and related technologies), shall prosper.

Let us consider another example of a disruptive business model. T-mobile provides cell phone service in America. They are widely regarded as having a lower quality cell phone network, but is a leader in WiFi hot spots. They have now launched a service where cell pone calls will be routed over the internet and then the WiFi network.

I personally make the bulk of my cell phone calls either at home or at school. In both places, I have access to a WiFi network. This service will help me reduce my cell bill and is thus attractive to me [52].

T-mobile has created a business model which could be disruptive for the leading cell phone providers.

Going back to cable and telco, the jury is still out on which side will take advantage of this situation.

Perhaps, a telco or the cable providers could conceive a business scenario where one of the platforms becomes more powerful because of some type of synergistic relationship with WiFi.

Other miscellaneous comments

During my research I learned about a company that will sell a device to you for a one time fee and then you can make unlimited calls long distance calls for free. The device works in conjunction with your phone service. Ooma (www.ooma.com) plans to launch the service in Fall 2007.

Consider a case where a consumer gets their phone service from Verizon. I would be one such subject. Verizon gets two types of revenues from the phone subscriber:

- Fixed monthly fee for providing service.
- Usage based fee for making toll calls.

If the user signs up for Ooma the following interesting aspects should be noted.

- She continues to be a Verizon phone customer.
- Verizon's revenue and profit from the user has been curtailed because usage based fee for toll calls may drop to zero.
- The more the Verizon network improves, the better the quality of the service provided by Ooma.
- If Ooma is successful, Verizon will either have to reduce the price of long distance calls or give up on that segment. This is a bad situation.

I have coined the term "*Disruptive Parasite*" to describe such a player. I suspect that such companies will play an important role in the growth (or lack there of) of telco/cable platforms in the future.

Interestingly, in a working paper, Hagiu has described the inefficiencies associated with the multi sided platform model [70]. The author claims that in several cases, a one sided platform will provide more value to the customer. This will keep the IPTV platforms under constant attack from niche layers who are trying to provide a subset of all the services that they provide. They need to be looking out for players, attempting to bite off a portion of the platform for themselves!

5.2.4 Which side is managing its ecosystem better?

Michael Porter introduced us to the concept of *value chain* [72]. A primary implication was that a successful business needed to manage components outside itself to enjoy growth and profitability. Several companies, most notably Dell and Wal-Mart have executed on this concept and acknowledged to be leaders in this area.

In 1993, James Moore wrote a seminal article describing the concept of a *business ecosystem* [71]. He compared business environments to biological ecosystems. Moore's conclusion was that successful companies need to manage more components than those covered by Michael Porter's Value chain. They needed to take care of the business ecosystem,

Both the cable and telco platforms compete in a complex ecosystem with several complementors. How should they best manage this ecosystem?

Recent research in the field of ecosystem has created the concept of a "*Key stone organization*". Such an organization creates value by offering a platform that ecosystem players can leverage to provide goods and services. Further, such an organization is generous in sharing the economic rents of the value thus created. The keystone strategy should be the preferred mode of operation in the following environment [69]

- Level of turbulence and innovation in the industry is high.
- Complexity of relationships between industry players is high.

This relationship is also captured by the grid below. The figure is copied in Verbatim from the HBR article referenced here:

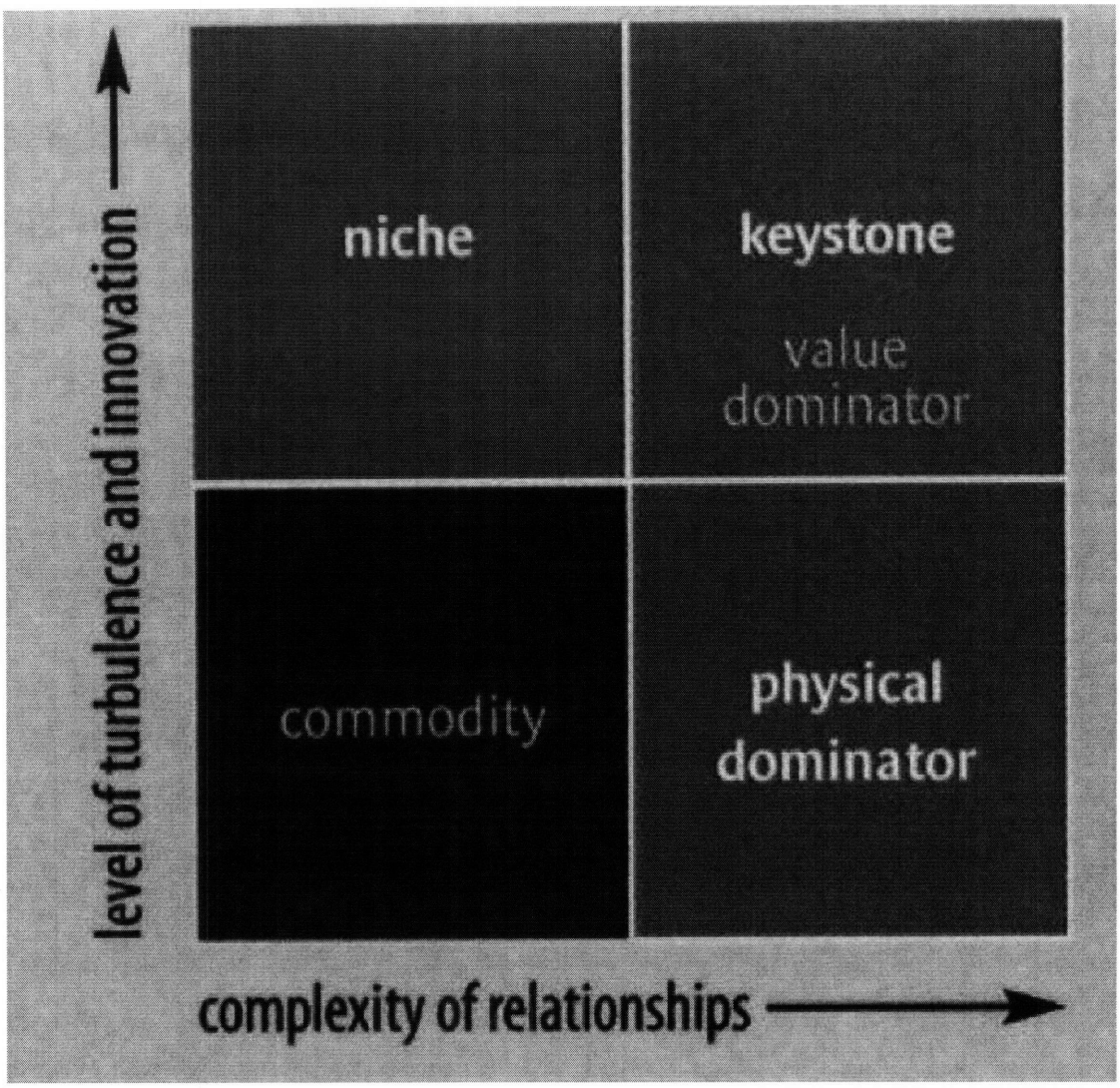

Figure 24: Ecosystem Strategy [69]

Another important reference for ecosystem strategy is the work of Yoffie and Kwak, focused on complementors. Complementors are an important part of the industrial ecosystem and are defined as companies that develop goods and services, which reinforce the goods or services that the ecosystem leader provides. In addition, the complementors will provide these goods or services directly to the customer. The presence of complementors increases the value of the services provided by the leader [62].

The cable and telco platforms operate in an industry with the following two characteristics:

- Need for a variety of complements is high.
- Capability to invest is high.

In this environment, the leader should be developing some of the complements themselves, but rely on third parties to develop most of the complements [62].

Is there a tipping point resulting from ecosystem management?

I was unable to find any significant information which leads me to believe that one side is doing a superior job compared to the other.

Poor management of ecosystem relationship by either telco or cable will result in the market tipping in favor of the other side.

5.3 Platform Comparison: Gawer and Cusumano Levers

I introduced these four levers in chapter 2. These levers represented the starting point of my research. These levers are very useful in capturing the dynamics of platform competition.

In this section, we shall apply the four levers to telco and Cable. This analysis is captured in the table below:

Lever	Telco	Cable

Lever	Telco	Cable
Scope	Telco companies have impressive R&D capabilities, particularly AT&T. In my opinion, most of the innovation takes place outside the telco provider. It happens in companies developing product and services for Telco.	Cable seems to rely more on outsiders, as there is no equivalent of ATT research labs. However, Cablelabs does a great job managing the development of standards and driving innovation. This organization is controlled by the MSOs. They work closely with equipment developers here.
Product Technology	Since the platforms are standards based, technically they are open. Telco related research is also done on university campuses.	Since the platforms are standards based, technically they are open. Cable standards process is more "controlled". I found very little evidence of university level research

Lever	Telco	Cable
		here.
Relationship with external complementors	Largely collaborative	Largely collaborative
Internal Organization	Unknown	Unknown

Table 10: Gawer and Cusumano Levers

5.4 Platform Comparison: Platform Metrics.

A central tenant of my research is that superiority of product platforms provides a significant competitive advantage for the platform leader/owner. In this section I describe a comparison framework. And then I apply this framework to compare telco IPTV with cable IPTV. Platform management principles described in the table below are taken from Meyer and Lehnerd [3]:

Criterion	Telco IPTV	Cable IPTV

Criterion	Telco IPTV	Cable IPTV
Evidence of product family planning and platform based approach: • Is there a common thread between various products? • Is there a common thread binding the various platform components together?	The telco platform uses a common infrastructure to deliver all services to the consumer. This represents a common thread bindings the platforms together. The presence of a common thread is also evident from the bundling of products and services.	Same comments apply for cable.
Is the platform designed for field usage, service and install?	Yes	Yes
Is the platform designed to work in different nations and under different	The platform is specific to North America though variants are successful in	Platform is customized for the North America, though similar standards and

Criterion	Telco IPTV	Cable IPTV
technology standards? As an example, any laptop that you buy today probably can deal with the difference in voltage from US to Asia. It will work at 110 volts as well as 220 volts. Are platform components modular in nature? Are the interfaces clearly defined? Are the components plug and play? Are the interfaces based on peer reviewed or standards based specification?	other nations, most notably Japan and Hong Kong. I established during the architecture review that the components are modular, interfaces are well defined and are standards based. I found that the standards process in the telco environment is more open and more cumbersome. The cable standards process is more controlled and more efficient. All the work is managed by Cablelabs, a company controlled by the large Cable providers. In my opinion this is an advantage for the cable companies. The cable platform thus, is less open! Interestingly, research at HBS also suggests that open platform may be less	services are available outside North America, particularly in Europe. Platform architecture is modular. The interfaces are well defined and are standards based

Criterion	Telco IPTV	Cable IPTV
	efficient then closed platforms [70]!	
Does the service provided by the platform cater to the needs of the customer?	Yes	Yes
Does the platform encourage the discovery of new/latent needs in the customer?	Yes	Yes
Is the organization structured to deal with the needs of a platform, and the inherent need to manage the various parts that comes with it? Are company executives focused on the success of the platform or that of a single product?	Unknown	Unknown

Criterion	Telco IPTV	Cable IPTV
Does the company use the same platform for multiple segments? Or does it modify the platform for various segments?	The same platform is used for various market segments	Same for cable.

Table 11: Platform Comparison

5.5 Strategy for competing in multi sided market.

To wrap this chapter up, I will provide some specific pointers to competitive moves that the platform leader can make to gain supremacy. For this analysis I researched economic modeling done for two sided markets and platforms. Mark Armstrong in the UK divides two sided markets into three broad types:

- A *monopoly platform* is one where only a single platform is dominant. User groups and users (Armstrong calls them Agent Groups and Agents respectively) can decide whether they want to engage or not [66] [67].
- A *two sided single homing* platform is one where two platforms exist but the agents are single homing. They can join only one platform [66] [67].
- *Competitive bottleneck* platforms are such that one group of agents can multi-home, while the other group can only single home [66] [67].

Unfortunately the IPTV platforms do not easily follow this division. Some of the content providers multi-home and other do not. Similarly, users and advertisers can fall in either category. To make it even more complicated, a given agent can be both multi-homed and single-homed at the same time!

For example, I have services from both Verizon and Comcast in my home so I am multi-homing, but I am using the two platforms for different services, in that way I am single homing!

In previous sections, we have established that both platforms will coexist though; each will try to become dominant and hope to achieve a monopolistic position. In this section we will try to help them reach that!

For the purpose of this section I will make the following three simplifying assumptions:

- Cable and Telco platforms are two sided.
    - While cable and telco are three sided platforms, I will ignore the advertisers for now. This will make the platforms two sided.
- Cable and telco would like to be the sole/dominant market player.
    - Since both telco and cable platform leaders would like to derive maximum economic rent from their platforms, they both want to become the sole provider.
- All agents are single-homed!
    - This is obviously a major assumption but I am comfortable making it because if one platform attains complete dominates over another, or manages to differentiate itself, then agents will NOT have a need to multi-home.

Now that we have established these assumptions, let us write down some equations derived from Armstrong's work [66]. Let us consider the following nomenclature

Description	Symbol
Number of cable subscribers (agents)	$N^{Cable}_{Subscribers}$
Number of telco subscribers (agents)	$N^{Telco}_{Subscribers}$
Number of content providers to cable	$N^{Cable}_{Content\ Providers}$
Number of content providers to telco	$N^{Telco}_{Content\ Providers}$
Price charged by Cable (platform) to content provider.	$P^{Cable}_{Content\ Providers}$
Price charged by Telco to content provider to content provider.	$P^{Telco}_{Content\ Providers}$
Price charged by Cable (platform) to users.	$P^{Cable}_{Subscriber}$
Price charged by Telco (platform) to users	$P^{Telco}_{Subscriber}$
Benefit enjoyed by content provider when consumer consumes their product.	$\alpha_{Content\ Providers}$

Description	Symbol
(Network effects)	
Benefit enjoyed by consumer when content providers supplies content. (Network effects)	$\alpha_{\text{Subscriber}}$
The utility derived by the content provider from the cable platform.	$\mu^{\text{Cable}}_{\text{Content Providers}}$
The utility derived by the content provider from the telco platform	$\mu^{\text{Telco}}_{\text{Content Providers}}$
The utility derived by the subscriber from the cable platform.	$\mu^{\text{Cable}}_{\text{Subscriber}}$
The utility derived by the Subscriber from the telco platform.	$\mu^{\text{Telco}}_{\text{Subscriber}}$

I can now suggest the following equations from Armstrong's research [66]:

- $\mu^{\text{Cable}}_{\text{Content Providers}} = (\alpha_{\text{Content Providers}}) * N^{\text{Cable}}_{\text{Subscribers}} - P^{\text{Cable}}_{\text{Content Providers}}$
- $\mu^{\text{Cable}}_{\text{Subscriber}} = \alpha_{\text{Subscriber}} * N^{\text{Cable}}_{\text{Content Providers}} - P^{\text{Cable}}_{\text{Subscriber}}$

- $\mu^{Telco}_{Content\ Providers} = \alpha_{Content\ Providers} * N^{Telco}_{Subscribers} - P^{Telco}_{Content\ Providers}$
- $\mu^{Telco}_{Subscriber} = \alpha_{Subscriber} * N^{Telco}_{Content\ Providers} - P^{Telco}_{Subscriber}$

The next question is what should a platform provider do? They need to figure out how to increase the value the agents get from the platform. In other words they need to follow business strategies that maximize μ

Clearly reducing the price charged is an easy option. Unfortunately this reduces the providers profit and the provider runs the risk of a price war. Also, in some cases, the content provider may be charging a negative price! (The cable/telco platform may provide content for free, but they may have to pay to get content). However, the following steps can be useful in establishing dominance:

- Cable providers are also in the business of generating content. A great example is Time-Warner. If they make this content exclusive to cable platform, this will help them increase $N_{Content\ Providers}$ and thus increase utility provided to the Subscriber.
- Telco providers own wireless businesses. If they envelope the wireless platform, they can increase $N_{Subscriber}$. This will improve utility provided to the Content provider.
- You will notice that α is platform independent in this model. If the platform provider can change that, such that the value of α is greater on their platform they increase the utility variable. For example, Telco networks have higher access bandwidth. If that makes viewing a certain kind of content more pleasurable on the telco network, they have increased $\alpha_{Subscriber}$. In other words, if certain applications will run only on telco networks because they have higher bandwidth, we have increased $\alpha_{Subscriber}$. That in turn increases $N_{Subscriber}$ and increases $N_{Content\ Providers}$. Before you know, there is a positive loop!

Chapter 6
Conclusions and Recommendations

6.1 Concluding remarks

Cable and telco IPTV platforms have more similarities than differences. I suspect they will both co-exist and a tipping point will never be reached. In this chapter I will present some recommendations that the platform leaders can use to guarantee favorable market position for their platform.

6.2 Recommendations

In this section I provide specific recommendations for both platforms that will help them create more value. The first set of recommendations is common to both cable and telco. In subsequent sections I will provide recommendations specific to individual platforms.

6.2.1 Recommendations for both telco and cable

The following recommendations apply to both platforms and whoever executes better will probably gain competitive advantage:

Generic Recommendation	Explanation

Generic Recommendation	Explanation
Focus on Envelopment of adjacent market segments.	Both platforms need to figure out how to make the platform more valuable to all three agents. One way to do this is to subsume more functionality. This is not an easy task since new market segments may need a different set of core competencies. Please also note that envelopment can also take the form of partnerships. Several examples come to mind but I will only quote one. A large percentage of air travelers probably have a broadband access at home. They could be given the option of signing up for wireless access at airports. If you have Comcast cable mode, for an extra $5 you can internet access at Logan airport!
Attempt to become the low cost provider.	Both platforms are offering features which are very similar and in such an environment the price point becomes a major consideration.
Strengthen the positive network externalities between various agents.	How can getting a certain service, like internet access be more valuable for the consumer due to the presence of other

Generic Recommendation	Explanation
	agents on the platform? Unfortunately, today the benefit derived form the externality is similar across the two platforms. Both platforms should figure out how to approach this situation.
Provide Sticky Services	If a consumer thinks that switching costs are high they are less inclined to change service. For example, Comcast has created an online entertainment portal called the fan at Comcast.net. It also provides an industrial strength email service. These two features introduce a fair amount of inertia on the users' part. I know this because I have personally continued to use the service, despite being given cheaper offers from Verizon.
Look out for Niche player who use the platform to provide a service that the platform provides. (Disruptive parasites)	Telco and Cable are heavily focused on providing complete solutions. This may leave them vulnerable to disruptive players.

Table 12: Recommendations

6.2.2 Recommendations for Telco providers

The following recommendations apply to telco providers:

Recommendations for Telco Platform	Explanation
Aggressively market the fact that telco higher bandwidth in the access network.	Telco has a key advantage here. The access network is fiber optic and the cable network will have a really difficult time keeping up.
Invest in technologies/applications/services that can be effectively deployed and monetized in high band width networks only.	As I mentioned before, most applications and services today do not need the high bandwidth provided by FTTH. However, if such applications were to emerge, Telco would have a distinct, unbeatable advantage.

Table 13: Telco Specific Recommendations

6.2.3 Recommendations for Cable providers

The following recommendations apply to cable platforms:

Recommendations for Cable Platform	Explanation

Recommendations for Cable Platform	Explanation
Aggressively market the fact current applications and services run well on the cable network.	Refrain from absolute bandwidth comparison and focus on the services. Current set of services can work well with cable.
Leverage lower capital spending footprint to provide lower cost services.	I wonder if the lower level of capital spending can be used to provide cheaper class of services?
Cable providers also are content providers in some cases. Leverage that.	I am not suggesting that the content be made available to cable subscribers only. However, it may be cheaper, faster for cable to deploy cable generated content.

Table 14: Cable specific recommendations

6.3

6.4 Directions for future work

During my research I often explored a promising avenue, but would not pursue it too far because of various reasons. Two prominent reasons were:

- The research direction was out of scope for this effort.\

- The research direction was not going to provide significant insight for the platforms in question.

In this section I shall capture my work on some of those avenues which fall in one of the above two mentioned classes. These represent potential research areas for future work related to comparing technology platforms.

6.5 Quantitative comparison of platforms

Professor Katja Holtta-Otta at the University of Massachusetts, and her colleague Kevin Otto, have created a quantitative model for comparing platforms, termed the *Platform Assessment Tool* [4] [76]. During my research, I conversed with Professor Holtta-Otta and created a variant of her model. I hoped to use the model to compare the two IPTV platforms which I was researching.

My model is provided below for the sake of completeness. As mentioned before, this model is a variant of the Platform Assessment Tool. My intention was to run the model for Telco and Cable and then compare the output.

Mega-Platform Score Card		Weighted Contribution	Score	Grade
Product and Service Customer Satisfaction		20%	2.25	
Support, Service, Rollout		10%	1.75	
Alignment		10%	2	
Architecture		10%	2	
Misellaneous		20%	0.5	
Dummy Entry		0%	0	
	Total	70%	1.125	

Figure 25: Model Part 1, High Level Comparison Points

The model has several high level comparison points which are scored. The score for the high level items captured in the above figure are arrived at by scoring constituent lower

level items and then summing up the result. The lower level items are captured in the next figure below.

Product and Service Customer Satisfaction		Weighted Contribution	Score	Grade
Expressed needs at acceptable price point		25%	4	
Latent needs discovery		25%	3	
Cost Worth Distribution		25%	2	
Ease of Trial, entry and exit		25%		
Dummy Entry			0	
	Total	100%	2.25	
Support, Service, Rollout		**Weighted Contribution**	**Score**	**Grade**
Partitioning for Service		13%	4	
Partitioning for Reliability		13%	3	
Automated trobule shooting and self help.		13%	2	
Reliance on partners		13%	1	
Service cost to customer		13%	1	
Service cost to company		13%	1	
Environmental Friendliness		13%	1	
Ease of deployment and configuration		13%	1	
Dummy Entry			0	
	Total	100%	1.75	
Alignment		**Weighted Contribution**	**Score**	**Grade**
Ease of Assembly		17%	4	
Make Buy tradeoffs		17%	3	
System/component testability and conformance		17%	2	
Programming		17%	1	
Cross Selling		17%	1	
Intra and Inter organizational Synergy		17%	1	
Dummy Entry		0%	0	
	Total	100%	2	
Architecture		**Weighted Contribution**	**Score**	**Grade**
Change Flexibility		17%	4	
Function and Form alignment		17%	3	
Interface maturity		17%	2	
Interface flexibility		17%	1	
Redundancy		17%	1	
Technological advancements		17%	1	
Dummy Entry		0%	0	
	Total	100%	2	
Misellaneous		**Weighted Contribution**	**Score**	**Grade**
Regulation		25%	1	
TBD		25%	1	
Dummy Entry		0%	0	
	Total	50%	0.5	

Figure 26: Model Part 2, Lower Level Constituents

For example, *Support, Service, Rollout*, mentioned in Part One of the model, is a high level comparison point. This is composed of several lower level items. As an example *Partitioning for Reliability*, in Part 2, is a lower level item corresponding to Support, Service and Rollout. The lower level item is scored and then the aggregated score of all the lower levels is reported at the higher level item.

When the model is run for two competing platforms, the user can compare the scores and draw inferences about the superiority of one over the other. Sometimes, it helps to map the numerical result into a letter grade. I did not perform the mapping; hence the grade column is blank.

I ran into several issues when trying to use my model. I was not able to create finer granularity items for some of the high level bullets. This is evident from the TBDs in the model.

There were other roadblocks too. Often, when the question was applied to my research, the answers did not really provide a meaningful comparison between telco and cable. Perhaps, the quantitative model is better suited for comparing "product platforms" and is difficult to use for Mega Platforms.

Finally, it also became evident that the tool would be useful only when the person running it were familiar with detailed (even confidential) low level architecture of the platform. This person probably would also need access to past issues, performance data and other confidential/proprietary information. If I had access to that level of detailed information at a few Cable and Telcos I might have been able to use the model better.

6.6 Relationship with complementors: Perspective from the other side.

One of my key recommendations was for the platform leader to devices strategies for entry into adjacent market segments. This meant, that the platform leaders would be willing to swallow up complementors, if that increased value for the platform. Historically, this has been true for both Cable and Telco.

As an example, when DVRs became popular, the market leader was TiVo. A HBS case study captures the rise of the company and the issues it faced [74].

TiVo was a nice complementors to cable programming, as it let consumers watch programs on their own schedule. On one hand, TiVo probably increased viewer-ship since consumers were watching programming that they would not have seen otherwise. On the other hand, the platform leaders were threatened by this technology too. They eyed TiVo's recurring revenue stream and were worried about the impact on advertising.

Today, Comcast directly offers DVR equipment and services to its customers. In early 2005, TiVo announced that it would make a customized version of the device for Comcast. *This completed TiVo's transformation from complementors to a supplier!*

Comcast thus entered an adjacent market space and TiVo has suffered. Its stock price is languishing in the $5 range, a far cry from the $50 rage it traded in just 7 years ago! Please see figure below for TiVo stock price performance.

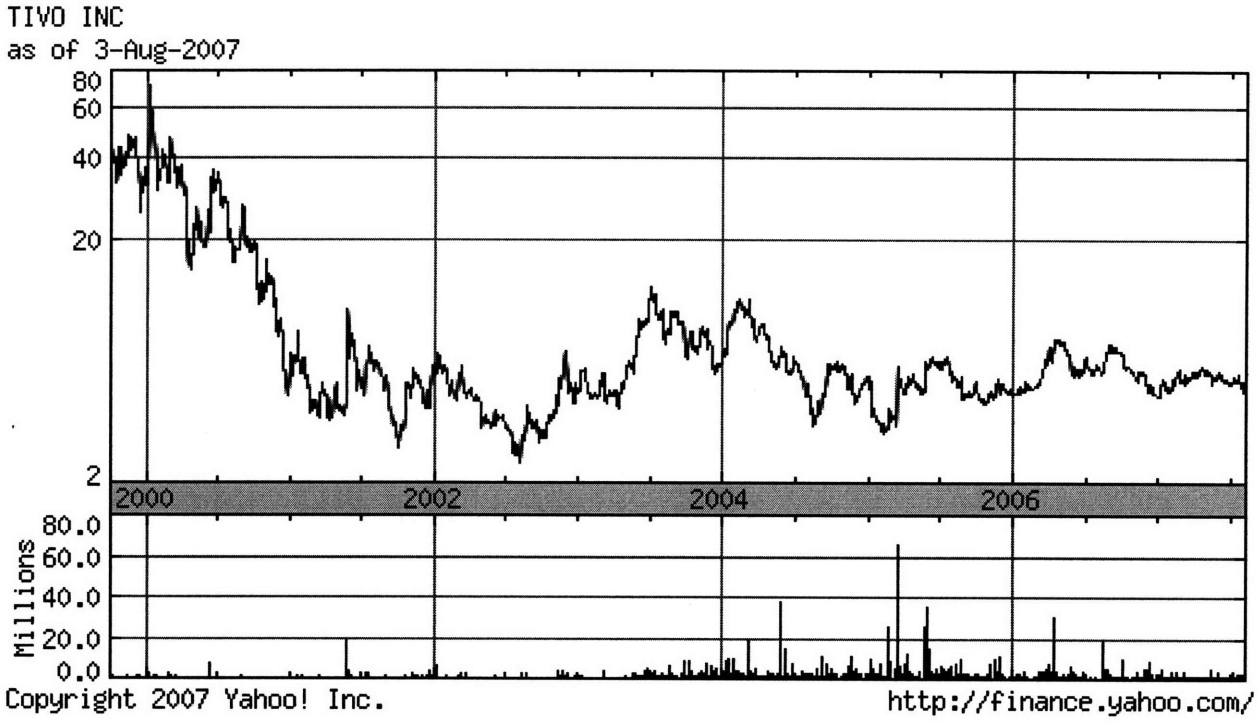

Figure 27: TiVo Stock Price Performance [77]

Is there a way for complementors to add value, but not provide the incentive to the platform leader to encroach upon their turf? What could TiVo had done differently to remain a complementors, and Comcast did not feel compelled to add a competing product to its platform?

Appendix: Questionnaire sent to industry experts

Revision One of Questionnaire

Both cable and telcos are in the business of delivering voice, video, data and sometimes wireless to the customer. The underlying technology in most cases is IP. My research is focused on IPTV, and how it enables the delivery of various services over a single platform.

Cable companies and telcos provide data, video and voice over IP, but there are differences. I am attempting to understand the technology and business differences. I have out together a questionnaire that will help me understand those deltas.

a. Verizon FIOS could provide a Gig of connection speed to the individuals' home. Is this a significant advantage over Cable service providers?
b. How can Verizon leverage its higher connection speed to the user home for business advantage over cable?
c. Telcos's like Verizon and AT&T are relatively new in the business of delivering video. How is this advantageous and disadvantageous? For example, are they able to develop better headend because they are new to video delivery?
d. Since Cable has been delivering video content for a while, they probably have existing relationships with content providers. How successful have the telco companies been in developing such relationships?
e. Would it be fair to say that most companies that supply equipment to cable companies also have relationships with telcos?
f. Does the service delivery platform rolled out by Verizon and AT&T encourage the discovery of new/latent needs in the customer?

g. Does the service delivery platform rolled out by cable companies like Comcast encourage the discovery of new/latent needs in the customer?
h. Are telco operators like Verizon and ATT, structured to deal with the needs of a platform, and the inherent need to manage the various parts that comes with it? Are company executives focused on the success of the platform or that of a single product?
i. Are cable operators like Comcast, structured to deal with the needs of a platform, and the inherent need to manage the various parts that comes with it? Are company executives focused on the success of the platform or that of a single product?

Revision Two of Questionnaire

Both cable and telcos are in the business of delivering voice, video, data and sometimes wireless to the customer. The underlying technology in most cases is IP. My research is focused on IPTV, and how it enables the delivery of various services over a single platform.

Cable companies and telcos provide data, video and voice over IP, but there are differences. I am attempting to understand the technology variations and business differences. I have put together a questionnaire that will help me understand those deltas.

j. Verizon FIOS could provide a Gig of connection speed to the consumers' home.
    i. Is this a significant advantage for Telco over Cable service providers?
    ii. How can Verizon turn this into a business advantage over cable?
k. Telcos like Verizon and AT&T are relatively new to the business of delivering video.

i. How is this advantageous and disadvantageous for Telcos? For example, are they able to develop better headends because they are new to video delivery?

l. Since Cable has been delivering video content for a while, they probably have existing relationships with content providers.
    i. How successful have the telco companies been in developing such relationships?

m. Would it be fair to say that most companies that supply equipment to cable companies also have relationships with telcos?

n. Service platforms from both Telco and Cable are capable of servicing existing customer needs.
    i. Does the Telco service delivery platform encourage the discovery of /latent customer needs?
    ii. Does the cable service delivery platform encourage the discovery of new/latent customer needs?

o. Are telco operators like Verizon and ATT, structured to deal with the needs of a platform, and the inherent need to manage the various parts that comes with it? Are company executives focused on the success of the platform or that of a single product?

p. Are cable operators like Comcast, structured to deal with the needs of a platform, and the inherent need to manage the various parts that comes with it? Are company executives focused on the success of the platform or that of a single product?

Response from Leonard Francis

Mr. Francis is a graduate student at MIT. Earlier in the year he was researching IPTV for his coursework. His focus was on the internet based IPTV services like Joost. I am reproducing his responses to my questions in verbatim below:

a. Verizon FIOS could provide a Gig of connection speed to the individuals' home. Is this a significant advantage over Cable service providers?

"Yes, this will be a significant advantage to Verizon over cable service providers. But keep in mind that Verizon will still need to do the other parts of the heavy lifting that is

- providing content to be transmitted on this high speed network.

- Providing the high speed backbone/servers to support and distribute content utilizing the full capacity of the network.

It appears that AT&T's Lightspeed, which does not use FIOS to the home but uses regular copper for the last mile (node to premises), is being scaled back as AT&T realize that they cannot provide full feature broadband as well as IPTV on the ~31 Mbps limit due to copper. [78]"

b. How can Verizon leverage its higher connection speed to the user home for business advantage over cable?

"Businesses can clearly use the higher speeds available via FIOS as more and more business processes simply use the web to either communicate or conduct operations. [78]"

c. Telcos's like Verizon and AT&T are relatively new in the business of delivering video. How is this advantageous and disadvantageous? For example, are they able to develop better headend because they are new to video delivery?

"I do not think AT&T is new, they have their cable service for a long time now (AT&T Cable Television, acquisition of MediaOne). That aside, comparing new TELCOs stepping into the entertainment (TV) arena delivering video, they have certain advantages as well as disadvantages of being new to the playground. The advantages are

- They can easily implement new delivery modes compatible to various video devices. There is a trend of the customers producing their own amateur videos (youtube and the likes) which these new players can easily support.

- They can support interactive mode of video distribution.

The disadvantages are

- No content bank or history of producing own content to attract customers. They will have to depend on other content producers which in some case will be existing cable companies.

- New entrants will have to learn to cater to viewer's choice starting from scratch. [78]"

d. Since Cable has been delivering video content for a while, they probably have existing relationships with content providers. How successful have the telco companies been in developing such relationships?

"Telco companies' relations with content providers can be described as barebones at the minimal. Their contracts with content providers is to provide the same content (regular cable channels) already available via cable networks. The telcos on their part are not making worthwhile efforts to trigger generation of new exclusive content that will drive customers to their video services. [78]"

e. Would it be fair to say that most companies that supply equipment to cable companies also have relationships with telcos?

"Yes, as both the telcos and cable operators move to a common platforms like IPTV, Digital simulcast, Video on Demand etc the equipment they need to provide these services, i.e. digital video (HD) will be the same and so the equipment suppliers to cable companies could be the same that supply to telcos.

Further, the expansion of cable companies in the VOIP arena brings them closer to telco equipment suppliers.

Looking at the downstream equipment suppliers, it looks like most large equipment suppliers are trying to capture both the markets due to similarity and projecting the advantage of being a one-stop location for all their digital data equipment needs. The supplier industry is seeing M&A activity in a rush to being able to fulfill all digital equipment needs. [78]"

f. Does the service delivery platform rolled out by Verizon and AT&T encourage the discovery of new/latent needs in the customer?

"The service delivery platform rolled out by the two companies does not seem to encourage discovery of latent needs of the customers. I would argue the other way round, that services from other video content providers (like youtube etc) is generating latent needs of customers, the latent need here being high internet speed to download all the videos.

Once IPTV takes a strong hold and more interactive TV (like live voting, discussing programs online while watching it, live questions from audience etc.) comes to the forefront it might encourage discovery of new needs of customers. [78]"

g. Does the service delivery platform rolled out by cable companies like Comcast encourage the discovery of new/latent needs in the customer?

"Other than the video–on-demand/pay-per-view rolled out by cable companies a few years ago I do not see any new services rolled out that encourages new needs of the customers. The video-on-demand/pay-per-view seems to have triggered the need to be able to watch what viewers want, when they want, which in turn gave rise to the era of TIVO.

On the other hand, cable companies entering the telecom area (VOIP) has simply created a downward push on phone services but has really not encouraged any new/latent needs. [78]"

h. Are telco operators like Verizon and ATT, structured to deal with the needs of a platform, and the inherent need to manage the various parts that comes with it? Are company executives focused on the success of the platform or that of a single product?

"It seems that telco operators just want to get their foot inside the door. They are trying their best to compete with cable operators breaking ground into the phone services field. As such they are focused on single service/products. They are trying to provide all the services that they can bundle and that their infrastructure can support but have not come up with any really innovative way of merging these services together. At the end I still watch sopranos on TV, shop amazon via my laptop and communicate to my friends via my phone service. The minimal they have done is provide me with the ease of just writing one check at the end of the month for their services instead of writing three checks to three different companies. [78] "

i. Are cable operators like Comcast, structured to deal with the needs of a platform, and the inherent need to manage the various parts that comes with it? Are company executives focused on the success of the platform or that of a single product?

"They are in the same boat as telcos, see answer 'h' above for telcos. [78]"

Response from Greg Thompson

Mr. Thompson is an MIT Alumnus and is the chief Architect of Cisco's Video products. He is uniquely situated to provide insight into the Cable and Telco industries, since they are both customers for Cisco products.

I am reproducing in verbatim, his responses to my questions:

Verizon FIOS could provide a Gig of connection speed to the individuals' home. Is this a significant advantage over Cable service providers?

"Not necessarily since a modern Hybrid Fiber Optic cable plant delivers 750 Mhz, 860 Mhz or even 1 GHz of bandwidth shared across only a 500 to 2000 homes passed neighborhood. With 256-QAM modulation delivering slightly more than 38 Mbps (after FEC) per 6 MHz channel, if all of the 50 to 750 MHz downstream spectrum could be leveraged (say via DOCSIS 3.0 channel bonding) that represents ~700/6 Mhz * 38 Mbps = 4.4 Gbps (or with 1 GHz systems up to 950/6 * 38 = 6 Gbps) of bandwidth shared across the 500 to 2000 homes-passed service group. How many actual homes might be sharing it depends on the service penetration (typically around 2/3rds today). At 50% penetration across a 500 home service group, that's 6 Gbps * 0.50 / 500 = 6 Mbps continuous per home.

While HFC networks today are saddled with inefficient use of this potential bandwidth due to carriage of NTSC analog video and fragmented spectrum allocation for different services, HFC does still represent significant potential bandwidth per home especially as service group sizes can also be subdivided below 500 homes as needed. While its less bandwidth than a fiber PONs-based FTTH/FTTB architecture can deliver, it is still significant compared to today's requirements and can be upgraded and leveraged into the future without having to invest in replacing the per home access network.

In comparison a Telco PONs network shares its 622 Mbps (BPONs) or 2.488 Gbps (GPONs) of downstream bandwidth shared across up to 32 (or even 64) homes depending on the passive optical split. That's 622/64 = 9.7 to 2.488/32 = 77 Mbps continuous per home.

In reality not all traffic needs to be unique, real-time, or continuous per subscriber. Sharing of content or streams via IP Multicast and time-shifted delivery is possible as well.

So in summary I am a believer that either HFC or FTTx/PONs is what a facilities-based service provider needs to delivery the high value services for the future. AT&T relying on just 2 pair bonded ADSL2+ access architecture I think is too short sited. They will likely find themselves re-upgrading their access networks in the not too distant time frame as HDTV continues to rapidly increase its penetration, especially if more than one HD set per home starts becoming more than just a rare exception.

Note that Verizon's architecture is actually a hybrid of HFC and xPONs with a third wavelength at 1550 nm delivery a full downstream spectrum of analog and digital RF broadcast channels very much like a mini-node HFC plant. It probably represented the best investment for the future even though Wall Street complains about all the up front costs they are incurring. [79] ["

b. How can Verizon leverage its higher connection speed to the user home for business advantage over cable?

"Well it certainly makes it easier to offer home office VPNs, video conferencing, and even home Telepresence in the future which given the time and cost of travel and commuting will become more and more important. Also as communities are more and more mixing small and high-tech business and residential communities together, it makes it much easier for Service Providers to directly offer services to small and medium business as well as home subscribers over the same network. [79]"

c. Telcos's like Verizon and AT&T are relatively new in the business of delivering video. How is this advantageous and disadvantageous? For example, are they able to develop better headend because they are new to video delivery?

"Disadvantages: Telcos didn't have the existing video expertise or relationships with content providers as cable operators have had. Also since they are still just starting to deploy their video services, they don't have the large subscriber base of eyeballs that advertisers, content owners, and vendors selling equipment want to see to help drive costs down.

Advantages: Telco don't have MPEG-2 based legacy installations and therefore can take advantage of the latest technology, such as MPEG-2 part 10 AVC / H.264 encoding, modern IP-STBs, and web services based technologies, much easier than their cable competitors. AVC encoding provides roughly a 2x reduction in bandwidth for the same quality, doubling what can be delivered in a given amount of access bandwidth. Also they can leverage the best practices already developed for the cable industry. For example Cisco's Scientific Atlanta company was contracted by AT&T to design and deploy all of AT&T's headends.

However most of the satellite broadcast channels are delivered in MPEG-2 today increasing headend costs of Telcos who then have to decode and then re-encode their channels in MPEG-4 AVC. This is starting to change with HBO announcing they are moving all their channels to MPEG-4 AVC encoding next year. Also satellite service like SES Americom (see www.ip-prime.tv/ipprime) is offering a full MPEG-4 AVC lineup of channels for medium and small tier Telcos. [79]"

d. Since Cable has been delivering video content for a while, they probably have existing relationships with content providers. How successful have the telco companies been in developing such relationships?

"Yes this is very important however content owners in general want as many distribution channels as possible for their content. I suspect they feel the development of a Telco channel in addition to DBS satellite, cable, and in some cases DVDs, theaters, and the web, represents additional competition for their content and puts themselves in an even better negotiating position. This is true as long as the operator or content aggregator represents a significant enough number of subscribers to be worth setting up a direct agreement.

Actually Verizon (and likely AT&T) have been very successful in negotiating access to high value content for their FiOS and U-verse TV services because they expect to represent a large enough subscriber base. Its the smaller operators that may find it more challenging, however content aggregation services like SES Americom (www.ip-prime.tv/ipprime), TVN (www.tvn.com), ViewNow (www.viewnow.tv), Federal Hill Communications (www.federalhill.tv), and Europe's On Demand Group (www.ondemand.co.uk) make it easier by acting as a content right acquisition middleman. [I would normally include In Demand (www.indemand.com) but they are owned by cable companies]. [79]"

e. Would it be fair to say that most companies that supply equipment to cable companies also have relationships with telcos?

"It depends on what equipment we are talking about. Companies supplying equipment such as video encoders, video-on-demand servers, and IP routers/switches for video transport sell to both groups in general. Some Set Top

Box vendors (such as Cisco's SA) sell both cable and IP-STBs. Others specialize in just cable, satellite, digital terrestrial, and/or IP-STBs. Companies selling access network technology would be happy to sell to both, but often just deal with Telcos or cable operators.

However the world is changing. Going forward service providers will less likely be characterized by the access technology they use but will likely start leveraging a variety of access technologies depending on the particular requirements and characteristics of the communities they serve. They are really becoming Experience Providers focusing on the triple or quad-play services they are now all able to offer over any capable IP-enabled access network to an increasingly wide variety of devices (TVs, PCs, PDAs, cell phones, etc.). [79]"

f. Does the service delivery platform rolled out by Verizon and AT&T encourage the discovery of new/latent needs in the customer?

"Yes since IPTV systems are really about the development and deployment of a programmable platform for the rapid delivery of a wide variety of video-based services and not any particular service. It should enable much more rapid innovation and deployment of new interactive services to TVs and other devices in response to the greater competitive environment enabled by IP networking and the broadband Internet environment. I suspect there will be a lot of experimentation of what services subscribers are willing to pay for, much like Comcast has been innovating with different VOD-based services the last few years. [79]"

g. Does the service delivery platform rolled out by cable companies like Comcast encourage the discovery of new/latent needs in the customer?

"As Telcos start rolling IPTV platforms from Microsoft and others, you can also expect cable operators to start rolling out next generation all digital cable set top boxes supporting an OCAP-based middleware environment (see www.opencable.com). It will provide a common nationwide iTV standard for cable and foster new interactive TV application development by operators, programmers, content owners and advertisers. [79]"

h. Are telco operators like Verizon and ATT, structured to deal with the needs of a platform, and the inherent need to manage the various parts that comes with it? Are company executives focused on the success of the platform or that of a single product?

"They are learning and are reaching out to various vendors to help them in the effort. Unlike earlier attempts to get into video (starting around 1993), I believe the Telcos are very serious this time. Voice technology such as VoIP and the loss of wireline voice and long distance revenues to mobile and other VoIP-based solutions have basically mandated this path for Telcos at this point in order to maintain their long term viability.

While they are initially focused at getting basic video broadcast, EPG, DVR and VOD services deployed, I believe they will need to quickly supplement their offering beyond the basics in order to successfully compete with DBS satellite, digital cable, digital terrestrial broadcast, and over-the-top broadband Internet TV providers (like Joost) in order to be successful. [79]"

i. Are cable operators like Comcast, structured to deal with the needs of a platform, and the inherent need to manage the various parts that comes with it? Are company executives focused on the success of the platform or that of a single product?

"Cable operators are not sitting still. Major cable operators such as Comcast, Time Warner, and Cox in the US, UPC and Telewest/NTL in Europe, and plus a number in Asia are all looking towards leveraging IP technology in a modern interactive cable-based TV service. However often cable operators in Europe and sometimes Asia will follow the lead of the big US cable operators Comcast and Time Warner. [79]"

Response from Wai Shun Lo

Wai Shun Lo is a research scientist at Harvard Business School's Asia Pacific research center. He is working with Professor Andrei Hagui on IPTV research related to PCCW in Hong Kong.

PCCW is a telco IPTV provider in Hong Kong, offering voice, video, data and cell phones. A competing telecom company is Hong Kong Broadband. They offer voice, video and data. Wai's answers are mostly from the perspective of these two players.

I am reproducing in verbatim, answers provided by Wai during a phone interview with him.

- Verizon FIOS could provide a Gig of connection speed to the consumers' home.
    - Is this a significant advantage for Telco over Cable service providers?

"PCCW provides a 6 Mbps pipe to customers. For non HD programming, television takes 4.5Mbps, and the phone takes 1.5 Mbps. For HD television programming 25 Mbps is needed. These numbers are much smaller than 1Gig.

In fact, Hong Kong broadband provides 1000Mbps speeds into customer homes and has not been successful in gaining market traction. [80]"

    - How can Verizon turn this into a business advantage over cable?

"The speed advantage is not going to result in a business advantage over cable.[80]"

- Telcos like Verizon and AT&T are relatively new to the business of delivering video.
    - How is this advantageous and disadvantageous for Telcos? For example, are they able to develop better headends because they are new to video delivery?

"One advantage is that the telco companies can design the architecture form scratch and avoid making the mistakes cable has made. They also are able to design a platform that is resistant to piracy.

Another advantage is that they are able to offer new and innovative service models. For example PCCW is offering a la carte pricing, something cable is unwilling or unable to do.

The disadvantage is that they do not have any experience dealing with content. [80]"

- Since Cable has been delivering video content for a while, they probably have existing relationships with content providers.
    - How successful have the telco companies been in developing such relationships?

"Content providers are happy with the relationship with PCCW.[80]"

- Would it be fair to say that most companies that supply equipment to cable companies also have relationships with telcos?

"No response. [80]"

- Service platforms from both Telco and Cable are capable of servicing existing customer needs.
    - Does the Telco service delivery platform encourage the discovery of /latent customer needs?

"From 1998 to 2000, Hong Kong Telecomm tired video on demand, but failed. PCCW learned from that and launched a pay TV service first, with plans to follow up with interactive TV.

NOW TV provides several interactive services, but cable does not. Telco network is better suited for handling interactive content. [80]"

- Does the cable service delivery platform encourage the discovery of new/latent customer needs?

"No response. [80]"

- Are telco operators like Verizon and ATT, structured to deal with the needs of a platform, and the inherent need to manage the various parts that comes with it? Are company executives focused on the success of the platform or that of a single product?

"Yes they do think of the platform model. This is a two sided platform (ignoring advertising) with subscribers and content providers on the two sides. One needs to have positive network effects to be successful.

PCCW gave subscribers free or low cost set top boxes to get subscribers on board, thus jumpstarting the positive network effect phenomenon. This strategy was indicative of platform thinking.

Another example was rolling out pay Television before interactive television. [80]"

- Are cable operators like Comcast, structured to deal with the needs of a platform, and the inherent need to manage the various parts that comes with it? Are company executives focused on the success of the platform or that of a single product?

No response.

Appendix: Analog communication

This section provides a copy of information on analog communication hosted by webopedia. The text is copied in verbatim from the web site [14];

"Also spelled analogue, describes a device or system that represents changing values as continuously variable physical quantities. A typical analog device is a clock in which the hands move continuously around the face. Such a clock is capable of indicating every possible time of day. In contrast, a digital clock is capable of representing only a finite number of times (every tenth of a second, for example). In general, humans experience the world analogically. Vision, for example, is an analog experience because we perceive infinitely smooth gradations of shapes and colors.

When used in reference to data storage and transmission, analog format is that in which information is transmitted by modulating a continuous transmission signal, such as amplifying a signal's strength or varying its frequency to add or take away data. For example, telephones take sound vibrations and turn them into electrical vibrations of the same shape before they are transmitted over traditional telephone lines. Radio wave transmissions work in the same way. Computers, which handle data in digital form, require modems to turn signals from digital to analog before transmitting those signals over communication lines such as telephone lines that carry only analog signals. The signals are turned back into digital form (demodulated) at the receiving end so that the computer can process the data in its digital format.[14]"

Appendix: Digitial TV quality levels

The informed reader will observe that "Digital TV" is actually an overloaded word and has several meanings. A high level primer is published by the US government and is reproduced below in verbatim for completeness.

"Digital Television (DTV) is a new broadcasting technology that will transform your television viewing experience. DTV enables broadcasters to offer television with movie-quality picture and sound. It can also offer multiple programming choices, called multicasting, and interactive capabilities.

Converting to DTV also will free up parts of the scarce and valuable broadcast spectrum. Those portions of the spectrum can then be used for other important services, such as public and safety services (police and fire departments, emergency rescue), and advanced wireless services.

TV stations serving all markets in the United States are airing digital television programming today, although most will continue to provide analog programming through February 17, 2009. At that point, full-power TV stations will cease broadcasting on their current analog channels, and the spectrum they use for analog broadcasting will be reclaimed and put to other uses.

The Commission's digital tuner rule specifies that as of March 1, 2007, all new TVs must include digital tuners. This rule prohibits the manufacture, import, or interstate shipment of any device containing an analog tuner, unless it also contains a digital tuner. Despite this prohibition on manufacture and shipment, retailers may continue to sell analog-only devices from existing inventory. As a result, at the point of sale, many consumers may not be aware that this

equipment will not be able to receive over-the-air-television signals after February 17, 2009.

There are many quality levels of digital television programming. The most common are:

Standard Definition TV (SDTV) - SDTV is the basic level of quality display and resolution for both analog and digital. Transmission of SDTV may be in either the traditional (4:3) or widescreen (16:9) format.

Enhanced Definition TV (EDTV) - EDTV is a step up from Analog Television. EDTV comes in 480p widescreen (16:9) or traditional (4:3) format and provides better picture quality than SDTV, but not as high as HDTV.

High Definition TV (HDTV) - HDTV in widescreen format (16:9) provides the highest resolution and picture quality of all digital broadcast formats. Combined with digitally enhanced sound technology, HDTV sets new standards for sound and picture quality in television. (Note: HDTV and digital TV are not the same thing -- HDTV is one format of digital TV.)

Analog	**Digital TV**	**High definition TV**

Date for final transition to digital is February 17, 2009. After that date, stations will only broadcast digital signals. Consumers will always be able to connect an inexpensive receiver, a set top box, to their existing analog TV to decode DTV broadcast signals. Set top boxes will not convert your analog TV to high-definition. Analog TVs will continue to work with cable, satellite, VCRs, DVD players, camcorders, video games consoles and other devices for many years.	Digital cable or digital satellite does not mean a program is in high-definition. Digital pictures will be free from the "ghosts" and "snow" that can affect analog transmissions. Multicasting is available. HDTV is available. Data streaming is available.	High-definition broadcasts offered. Best available picture resolution, clarity and color. Dolby theatre surround-sound. Dolby surround-sound. Wide screen "movie-like" format

Digital Television facts at a glance " [12]

Appendix Personal Video Recorder

Personal Video Recorder is a fancy title for a TiVO like device that uses digital storage to record television. I am providing additional details, in verbatim from SeachSMB.com.

"DEFINITION - A personal video recorder (PVR) is an interactive TV recording device, in essence a sophisticated set-top box with recording capability (although it is not necessarily kept on top of the television set). Vendors and media also refer to the units by these names: digital video recorder (DVR); personal TV receiver (PTR); personal video station (PVS); and hard disk recorder (HDR).
Like the familiar VCR, a PVR records and plays back television programs, but, unlike the VCR, it stores the programs in digital (rather than analog) form. Like a VCR, a PVR has the ability to pause, rewind, stop, or fast-forward a recorded program. Because the PVR can record a program and replay it almost immediately with a slight time lag, what seem to be live programs can be manipulated as though they were recorded programs (which they actually are). A PVR's capabilities include time marking, indexing, and non-linear editing. The PVR encodes an incoming video data stream as MPEG-1 or MPEG-2 and stores it on a hard disk within a device that looks much like a VCR.
Most PVRs come as part of a subscriber service that may or may not charge a monthly fee. The service enables such activities as searching for shows according to type (movies or baseball games, for example), choosing among video-on-demand (VOD) options, or doing shopping or banking. Service providers, such as TiVo and ReplayTV, may also sell PVRs. There are a number of PVRs on the market, including TiVo's DVR, SONICblue's ReplayTV, Sony's SVR-2000, and Philips' PTR. There are also products that offer similar functionality but are software-based (such as SnapStream Personal Video Station) or network-based. The Digital Video Broadcasting (DVB) Project is an

industry consortium dedicated to the development of standards for PVRs and other digital video technologies.

There are a number of controversial issues surrounding the capabilities that PVRs and similar technologies enable. For example, ReplayTV makes it possible to skip through commercials by using a 30-second "auto-skip" function. This capacity is popular with consumers, but not with advertisers. Another feature, the ability to download programming from the Internet and to send files to friends, is similarly unpopular with service providers, since it can enable a user who hasn't paid for a service (such as HBO) free access [30]."

Appendix: Conversations with ATT Researcher

Date: Sun, 15 Jul 2007 11:54:37 -0400 [11:54:37 AM EDT]
From: Shantnu Sharma at MIT <ssharma@sloan.mit.edu>
To: shankar@research.att.com
Cc: ssharma@sloan.mit.edu, cusumano@mit.edu
Subject: Hello from MIT Grad Student: your article on Cable Access from 2001
Headers: Show All Headers

Hello Mr Shankaranarayan,

I am graduate student at MIT and am currently working on my masters thesis. I am studying service and product platforms. Specifically I am comparing IPTV rolled out by telcos like Verizon/ATT with cable based offerings.

I read your article from 2001, titled "User-perceived Performance of Web browsing and Interactive Data in HFC cable access networks". This was a very well written article and I enjoyed reading it.

In this article you have concluded that cable HFC shared bandwidth is perhaps as effective as a dedicated link because of the concept of "ECR". Your simulations prove the point.

I was wondering if these results are still valid in today's environment. For example, when a user gets television over a DSL or a FTTH link, does the dedicated pipe have an advantage? Web browsing is bursty in nature with large periods of inactivity. This makes it easy to share a pipe across multiple users. Television on the other hand perhaps needs more dedicated bandwidth, particularly downstream towards the user. Does this reduce the opportunity for sharing bandwidth between consumers?

Any help that you can provide in this matter will be greatly appreciated.

Best Regards
--
Shantnu Sharma
MIT SDM Fellow
Alfred P. Sloan School of Management
MIT School of Engineering
978 239 8154

Date: Fri, 20 Jul 2007 16:02:10 -0400 [04:02:10 PM EDT]
From: "SHANKARANARAYANAN, N K (N K)" <shankar@research.att.com>Add to Address book (shankar@research.att.com)
To: Shantnu Sharma at MIT <ssharma@sloan.mit.edu>Add to Address book (ssharma@sloan.mit.edu)
Subject: RE: Hello from MIT Grad Student: your article on Cable Access from2001
Headers: Show All Headers

Shantnu,

Thanks for your interest in our paper. That was a while back and typical traffic models would have changed. The model used in that paper was interactive data. The results are accurate for that model. Besides the burstiness, interactive models involve a inactive period imposed by the user interaction rather than any natural period of "silence".

The main advantage of a shared channel is to extract advantages of offering (relatively) high rate / user experience to users who have periods of inactivity. As you correctly point out, things would be different for traffic such as streaming video (TV) or audio.

From the viewpoint of the model, the average rate is low if there is lot of inactivity, and the "broadband" feel of regular Web browsing still has relatively lower average rates. If the traffic is more like streaming or is constant, then two things come into play (a) there is less multiplexing or sharing gain from the shared channel, and (b) other than voice, the average rates tend to start creeping up based on user demand for better video and music quality. In the limiting case, the "ECR" for constant traffic will simply be total capacity divided by nomof users.

From what I know about the nature of packet video traffic, the sharing gains will be much less than (plain) web browsing traffic. If the video traffic is a dominant portion of the broadband user's traffic (such as in IPTV where it is the main traffic), then I expect little or no sharing advantage.

I would be interested in your findings. So let me know when you complete your study.

Regards and good luck.

- Shankar
- Show quoted text -

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